COMPARATIVE STUDY OF ANTHROPOMETRICAL CHARACTERISTICS OF INDIAN ELITE MALE THROWERS OF DIFFERENT THROWING EVENTS

ABSTRACT

THESIS

SUBMITTED FOR THE AWARD OF THE DEGREE OF

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IN

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BY

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Under the Supervision of

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ABSTRACT

Track and field consists of running, hurdling, jumping, and throwing events held between individuals and teams at indoor and outdoor meets. The running and hurdling competitions make up the track events, while the jumping and throwing contests comprise the field events. In many countries the sport as a whole is called *Athletics*.

The throws (Shot put, Discus, Javelin, and Hammer) are field events in athletics. They are measure for explosive strength (power) in a human being from ancient time to modern time. The throwers of shot put, Discus, Javelin and hammer differed greatly in physique from the other athletes. As a group, they are taller and heavier, with longer arms in relation to their legs. They had broader shoulders and broader hips even for their trunk size, and were somewhat fatter than the track athletes. Their proportions of legs to the trunk were similar to those of middle distance runners. In ancient time throws were used in hunting and warfare. In modern time throws are used for achieving awards or medals in National and International level competitions.

The greater size of the throwers in all dimensions contributes to increase the proportionally body weight of these athletes. The stresses of weight bearing in the case of throwers may be responsible for broadening their knee. The better development of the lean body mass will help them to provide the great strength required in the throwing events.

Sports sciences has a long history of studying physique. **Sheldon et al.** used photoscopic and anthropometric methods to describe individual physique as three different Somatotype viz; (i) Endomorphy (fatty: predominance of digestive organs, softness and roundness of contour throughout the body), (ii) Mesomorphy (muscular: predominance of muscles, bones and connective tissues) and (iii) Ectomorphy (predominance of surface area over body mass linearity). This method has basic shortcoming i.e., it does not quantify the various body dimensions, indices and ratios. The body profile technique of **Mc Ardle et al.** describes physique in terms of muscular and non-muscular components. The diversity in overall body dimensions can be compared among individuals or groups from that of reference man and reference woman.

The relationship of length to breadth, height to thickness, length-to-length etc. of various parts of body represents proportions. This importance of proportion becomes evident, when we want to compare particular body parts of two persons who are otherwise different in over all size. The proportions or ratio keeps one measurement constant in all subjects compared and evaluate the differences in the other measurements. The body proportion can be studied in various ways, but indices method is best for determining body proportions.

The general physical fitness of top ranking athletes has been evaluated. Proposals are coming up for the selection of potential athlete with the designs of tests and the body size predictions. Human growth and performance is also an important field in this regard. **De**

Garay et al. and **Klissoras** have worked out the genetic aspect of performance.

The physiological factors limiting one's performance in sports are also well known. It is the understanding of interaction of all these factors that helps in designing the way for selecting the children for appropriate game. The author desires a scientific basis of selection of athletes and sportsmen. One may not take it guaranteed that every child can be trained to be an Olympian, for there are a few persons who have a combination of the development of each requisite factor of the highest degree. The idea is to put the interested individual in a game or event in such a way so that he gives out the best of his abilities.

The purpose of this research work is to place the role of anthropometrical variables on the performance of Indian male throwers. The study is also attempting to evaluate the difference existing in anthropometrical profile of throwers engaged in different throwing events.

For the purpose of this study 25 elite male throwers of each Javelin, shot put, discus and hammer throw were selected from various National and Inter-National Tournaments, State and SAI hostels and India Camp.

The selected subjects belonged to the 15 states of India. Namely -U.P, Punjab, Harrying, Delhi, Bihar, Chhatishgarh, Jharkhand, Karnataka, Kerala, M.P, Maharashtra Uttaranchal, J&K, West Bengal, A.P, T.N.

The criterion measures for this study were-

Weight – Kilogram, Anthropometrical parameters - Centimeter and mm., Proportionality (indices) – Ratios, Somatotype - Grading., Body composition in mm. % percentage.

The study was delimited to the following anthropometrical parameters of the four groups of throwers.

Weight, Height, Sitting Height, Femur Biepicondylar diameter, Humerus Biepicondylar Diameter, Hip Breadth, Shoulder Breadth, Total age, Total Arm Length, Wrist Breadth, Training age, Biceps Muscle Girth, Calf Muscle Girth, Thigh Length, Forearm muscles girth, Chest girth, Chest depth, Total leg length, Lower leg length, Upper leg length, Lower arm length, Upper leg length, Triceps skin fold, Suprailiac skin fold, Sub-scapular skin fold, Thigh skin fold, Body composition

Somatotype: Heath caters method (1984).

Body proportionality: 1) Sitting height - stature index, 2) Ponderal index, 3) Thigh length - lower leg length index, 4) Upper arm length - lower arm length index, 5) Hip breadth - stature index, 6) Shoulder breadth - stature index.

Product moment correlation technique, analysis of variance and LSD test were used to find out the significant differences and relationship among above mentioned delimited existing variable of different groups of throwers, and their performances.

The statistical analysis reveled significant differences among the following variable of different throwers, the results of LSD test in descending order are presented below:

1) **Weight** - Shot put<discus<hammer<javelin,

2) **Height** - Discus<shot put< javelin< hammer,

3) **Femur Biepicondylar diameter-** Shot put< discus< hammer <javelin,

4) **Humerus Biepicondylar Diameter**-Shot put<discus<javelin <hammer,

5) **Hip Breadth**-Shot put<discus < javelin < hammer,

6) **Shoulder Breadth**- Shot put <javelin <hammer < discus,

7) **Total Arm Length**-Javelin<discus< shot put < hammer,

8) **Wrist Breadth**- Shot put<javelin<discus< hammer,

9) **Skin Fold**- Shot put< hammer<discus<javelin,

10) **Biceps Muscle Girth**- Shot put< discus<hammer < javelin,

11) **Calf Muscle Girth**- Shot put<discus<hammer <javelin

12) **Thigh Length**- Shot put<discus< javelin<hammer,

13) **Forearm muscles girth**- Discus<shot put < hammer<javelin,

14) **Chest girth**- Shot put<hammer< discus< javelin,

15) **Chest depth**- Shot put<discus<hammer<javelin,

16) **Total leg length**- Discus<hammer < javelin < shot put,

17) **Endomorphy**- Shot put<Hammer<Discus<Javelin,

18) **Mesomorphy**- Shot put<discus< javelin<hammer,

19) **Ectomorphy** - Javelin <discus<hammer< shot put,

20) **Ponderal Index**- Javelin< discus < hammer < shot put,

21) **Upper arm length-lower arm length**- Shot put < javelin < hammer < discus,

22) **Hip breadth-Stature index**- Shot put< discus< javelin< hammer,

23) **Shoulder breadth-Stature index** - Hammer < javelin < shot put< discus.

24) **Fat Percentage** - Shot put < discus < javelin < Hammer .

The statistical analysis revealed insignificant differences among the following variable of Shot put, Discus, Javelin and Hammer throwers.

1) **Total age**
2) **Sitting height**
3) **Sitting height –stature index**
4) **Thigh length –lower leg length index**
5) **Foot length**

Further correlation ship between variables of different groups of throwers and their performance was find out through product moment correlation technique, the inter group comparison of correlation between selected variables of different groups and their performances are given in table-168.

INTER GROUP COMPARISONS OF CORRELATION

Table-168

VARIABLES	SP	DT	JT	HT
Total age & total training	0.38	0.19	0.07	0.55
Height-	0.31	-0.13	0.15	0.26
Weight	0.72	0.51	-0.33	0.23
Sitting height	0.09	0.45	-0.08	0.6
Chest girth & depth	0.45	-0.33	0.4	0.19
Humerus & femur-biepicondylar	0.75	0.74	-0.19	0.28
Wrist & Ankle breadth	0.66	-0.29	- 0.15	0.17
Hip & Shoulder breadth	0.12	-0.14	0.05	0.17
Upper arm length	0.57	-0.22	-0.29	0.23
Lower arm length	0.26	0.04	-0.39	0.06
Total arm length	0.76	0.1	-0.03	0.83
Upper leg length	0.49	-0.38	0.23	0.12
Lower leg length	0.37	-0.32	0.46	0.02
Total leg length	0.08	0.05	0.26	0.31
Muscles girths	0.87	-0.33	0.32	0.09
Skin folds	0.55	0.08	0.06	0.22
Endomorphy	0.43	0.11	0.06	0.15
Mesomorphy	-0.22	-0.33	0.12	-0.04
Ectomorphy	-0.48	0.37	0.25	-0.3
Sitting height-stature Index	0.19	0.22	-0.18	0.24
Ponderal Index	-0.48	0.37	0.23	-0.3
Thigh Length–Lower Leg length Index	0.04	0.02	-0.18	0.07
Upper arm length-Lower arm length	0.38	-0.3	0.23	0.24
Hip breadth-Stature Index	-0.06	-0.46	0.14	-0.11
Shoulder breadth-Stature Index	0.04	-0.34	-0.34	0.02
Fat Percentage	0.54	0.09	0.16	0.03
Foot length	-0.018	-0.002	-0.36	0.207

The review of various research studies in light of our finding is leading us to conclude that the observed significant differences in the various anthropometrical variables of different throwers are decisive determinants of the performance limits binding these throwers. Which is confirming the fact that competitive sport, demands events specific physical structure.

A top-level performance demands a particular type of body size shape and proportion. Numerous researchers had observed high co-relation between the body profile of athletes and performance in specific tasks. Hirata had suggested that nation with people whose general physique is limited to the characteristics of champions in certain events must concentrate their training program on those events only.

Carter had also suggested that the athletes who wish to achieve success in sports at high level must compare their physique with Olympic athletes.

Thus our findings are setting guideline for coaches and up-coming athletes for comparing their physical structure with the different throwers of our country. If their structure is inline with the high performers then they may also achieve their status, subject to the optimization of other factors.

CONCLUSIONS

After going through the analysis of results in light of literature available, we are able to draw following conclusions:

1. The Shot putters are having greater weight and chest depth than Discus throwers followed by Hammer and Javelin throwers.
2. The Discus throwers are having greater height than Shot putters followed by Javelin and hammer throwers.
3. The Discus throwers are having greater sitting height than Javelin throwers followed by Shot put and Hammer throwers.
4. The Shot putters are having greater femur Biepicondylar diameter than Discus throwers followed by Hammer and Javelin throwers.
5. The Shot putters are having greater humerus biepicondylar diameter than Discus throwers followed by Javelin and Hammer throwers.
6. Shot putters are having greater hip widths and thigh lengths than Discus throwers followed by Javelin and Hammer throwers.
7. Shot putters are having greater shoulder breadth than Javelin followed by Hammer and Discus throwers.
8. Discus throwers are having greater total age than Javelin throwers followed by Hammer thrower and Shot putters.
9. Javelin throwers are having greater total arm length than Discus throwers followed by Shot put and Hammer throwers.
10. Shot putters are having greater wrist breadths than Javelin throwers followed by Discus and Hammer throwers.

11. Shot putters are having greater skin fold thickness than Hammer throwers followed by Discus and Javelin throwers.
12. Shot putters are having greater biceps and calf muscle girths than Discus throwers followed by Hammer and Javelin throwers.
13. Discus throwers are having greater forearm muscle girths than Shot put throwers followed by Hammer and Javelin throwers.
14. Shot putters are having greater chest girth than Hammer throwers followed by Discus and Javelin throwers.
15. Discus throwers are having greater total leg length than Hammer throwers followed by Javelin and Shot putter.
16. Shot putter are having greater endomorphy than Hammer throwers followed by Discus and Javelin throwers.
17. Shot putters re having greater mesomorphy than Discus throwers followed by Javelin and Hammer throwers.
18. Javelin throwers are having greater ectomorphy and ponderal index than discus throwers followed by Hammer and Shot put throwers.
19. Javelin throwers are having greater sitting height – stature index than discus throwers followed by Shot put and Hammer throwers.
20. Javelin throwers are having greater thigh –lower leg length index than Shot putter followed by Hammer and Discus throwers.
21. Shot putters are having greater Upper arm length –lower arm length index than Javelin throwers followed by Hammer and Discus throwers.

22. Shot putters are having greater hip breadth-statute index than Discus throwers followed by Javelin and Hammer throwers.
23. Hammer throwers are having greater shoulder breadth- stature index than Javelin throwers followed by Shot put and Discus throwers.
24. Shot putters are having greater Fat % than Discus throwers followed by Javelin and Hammer throwers.
25. Positive correlations were observed between the following variables of Shot putters and their performances

- Total age & training age (0.38)
- Height (0.31), Sitting height (0.09)
- Weight (0.72)
- Chest girth &depth (0.45)
- Humerus &femur- biepicondylar (0.75)
- Wrist & ankle breadth (0.66)
- Hip &shoulder breadth (0.12)
- Upper arm length (0.57), lower arm length (0.26) and total arm length (0.76)
- Upper leg length (0.49), lower leg length (0.37), and total leg length (0.08)
- Muscle girths (0.87)
- Skin folds (0.55)
- Endomorphy (0.43)
- Sitting height –stature index (0.19)
- Thigh length –lower leg length index (0.04)
- Upper arm length –lower arm length index (0.38)

- Shoulder breadths-stature index (0.04)
- Fat % (0.54)

26. Negative correlations were observed between the following variables of Shot putters and their performances.
    - Mesomorphy(-0.22)
    - Ectomorphy (-0.48)
    - Ponderal index (-0.48)
    - Hip breadth –stature index (-0.06)
    - Foot length (-0.018)
27. Positive correlations were observed between the following variables of Discus throwers and their performances.
    - Total age & total training age (0.19)
    - Weight (0.51)
    - Sitting height (0.45)
    - Humerus &femur-biepicondylar (0.74)
    - Lower arm length (0.04)
    - Total arm length (0.1)
    - Total leg length (0.05)
    - Skin folds (0.08)
    - Endomorphy (0.11)
    - Ectomorphy (0.37)
    - Sitting height-stature index (0.22)
    - Ponderal index (0.37)
    - Thigh length –lower leg length index (0.02)
    - Fat % (0.09)

28. Negative correlations were observed between the following variables of Discus throwers and their performances.

- Height (-0.13)
- Chest girth &depth (-0.33)
- Wrist & ankle breadth (-0.29)
- Hip &shoulder breadth (-0.14)
- Upper arm length (-0.22)
- Upper leg length (-0.38)
- Lower leg length (-0.32)
- Muscles girths (-0.33)
- Mesomorphy (-0.22)
- Upper arm length –lower arm length index (-0.3)
- Hip breadth –stature index (-0.46)
- Shoulder breadth –stature index (-0.34)
- Foot length (-0.002)

29. Positive correlations were observed between the following variables of Javelin throwers and their performances.

- Total age &total training age (0.07)
- Height (0.15)
- Chest girth &depth (0.4)
- Hip & shoulder breadth (0.05)
- Upper leg length (0.23)
- Lower leg length (0.46)
- Total leg length (0.26)
- Muscles girths (0.32)
- Skin folds (0.06)

- Endomorphy (0.06)
- Mesomorphy (0.12)
- Ectomorphy (0.25)
- Ponderal index (0.23)
- Upper arm length –lower leg length index (0.23)
- Hip breadth –stature index (0.14)
- Body composition (0.16)

30. Negative correlations were observed between the following variables of Javelin throwers and their performances.

- Weight (-0.33)
- Sitting height (-0.08)
- Humerus & femur biepicondylar (-0.19)
- Wrist &ankle breadth (-0.15)
- Upper arm length (-0.29)
- Lower arm length (-0.39)
- Total arm length (-0.03)
- Sitting height –stature index (-0.18)
- Thigh length –lower length index (-0.18)
- Shoulder breadth –stature index (-0.34)
- Foot length (-0.36)

31. Positive correlations were observed between the following variables of Hammer throwers and their performances.

- Total age & training age (0.55)
- Height (0.26)
- Weight (0.23)
- Sitting height (0.6)

- Chest girth &depth (0.19)
- Humerus &femur biepicondylar (0.28)
- Wrist and ankle breadth (0.17)
- Hip and shoulder breadth (0.17)
- Upper arm length (0.23)
- Lower arm length (0.06)
- Total arm length (0.83)
- Upper leg length (0.12)
- Lower leg length (0.02)
- Total leg length (0.31)
- Muscles girths (0.09)
- Skin folds (0.22)
- Endomorphy (0.15)
- Sitting height –stature index (0.24)
- Thigh length –lower leg length index (0.07)
- Upper arm –lower arm length index (0.24)
- Shoulder breadths –stature index (0.02)
- Body composition (0.03)
- Foot length (0.207)

31. Negative correlations were observed between the following variables of Hammer throwers and their performances.

- Mesomorphy (-0.04)
- Ectomorphy (-0.3)
- Ponderal index (-0.3)
- Hip breadth –stature index (-0.11)

RECOMONDATION

In light of the findings of our study following recommendation are made-

(1) The findings of the study should be taken into consideration while going for talent hunts for probable high potential throwers of different throwing events.

(2) Along with physical and physiological parameters, psychological and mechanical parameters of different throwers should also be studied.

(3) Further, a study should be conducted to compare elite male Indian throwers with the rest of world selected throwers in relation to physical, physiological and mechanical parameters.

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DEDICATED

To

My Father

(Late) Mr. Om Prakash Singh

&

Mother

Mrs. Shyama Devi

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CERTIFICATE

I certify that the thesis entitled, **"Comparative study of Anthropometrical characteristics of Indian Elite male Throwers of different throwing events"** is the original work carried out by **Mr. Dau Dayal** under my supervision. It is suitable for submission for the award of degree of doctor of philosophy in physical Education.

(Dr. Brij Bhushan Singh)
Supervisor

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I also thanks various national and international athletes who allowed me to take anthropometric measurements, their names are given in appendix.

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(DAU DAYAL)

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Introduction

Introduction

The human physique differs in a thousand ways. It can be analyzed by studying the size, shape and form of an individual. For this purpose, sets of selected anthropometric measurements are taken on an individual. The Inter group comparisons are made to understand the physical peculiarities of a population. From such body measurements, it is also possible to estimate the distribution of fat and development of bone and muscle in one's body. This is known to be more important in the case of athletes and sportsmen where the physical fitness plays a vital role in the competitive performance.

The competitive sports demand event specific physique and body composition to achieve the success. **De Garay et al.** concluded that top-level performance in a particular event demands a specific type of size and shape, if other aspects are being similar. They showed high correlation between the body profile of an athlete and specific task (event) in which he/she excelled. Various other studies also suggest that different body size, shapes and proportions are beneficial in different physical activities. **Hirata** suggested that a nation with people whose general physique is limited to the characteristics of champions in certain events must concentrate their sports training on those specific events. He also concluded that Japanese with small body-builds are best for gymnastics, long distance running, boxing and weight lifting etc. whereas the Americans who are large and lean are best for basketball, Volleyball, Swimming, long jump, short and middle distance running.

Carter suggested that the athletes who wish to achieve success in sports at a high level should compare their physique with Olympic athletes.

If the athlete's bodily structure is with in the limit of the Olympians, he/she may achieve high performance subjected to the optimization of other factors. **Behnke** and **Royce** concluded that long distance runners are characterized by excessive leanness, relatively small body size and a deficiency of arm girth compared to chest size and leg length. The anthropometric and compositional study on cross-country runners revealed that runners are characterized by a relatively large calf and small biceps and abdominal girths.

Body composition is an important morpho-physiological characteristic. Several scientists have explained the methodology for the measurement of body composition. Fat fold measurement can provide fairly consistent and meaningful information related to body fat and its distribution. The sum of 'fat fold' is an indicator of relative degree of fatness among individuals. **Mc Ardle et al.** pointed out that exercise-induced changes in fat fold values can be evaluated either as absolute or percentage basis. **Peterson** pointed out that body fat is a very personal datum and it is strongly recommended that that this information is presented discreetly.

Various scientists have extensively studied the body composition of athletes. **Leasy et al.** Concluded that physical performance, in which whole body moves, primarily depends on lean body mass (LBM). They developed regression equation for calculating body composition from performance in various tests (pull-ups, standing broad jump). **Prizkova** pointed that the proportion of lean body mass to fat is an indicator of degree of fitness for performance.

Contrary to these reports, **Uppal and Ray** in their study on strength, body composition and performance of shot put and javelin throwers,

concluded that there was no significant relationship in body density, lean body mass and body fat percentage to performance.

Sports sciences have a long history of studying physique. **Sheldon et at.** Used photoscopic and anthroposcopic methods to describe individual physique as three different somatotype viz.; (i) Endomorphy (fatty: predominance of digestive organs, softness and roundness of contour throughout the body), (ii) Mesomorphy (muscular: predominance of muscles, bones and connective tissues) and (iii) Ectomorphy (predominance of surface area over body mass linearity). This method has basic shortcoming i.e., it does not quantify the various body dimensions, indices and ratios. The body profile technique of **Mc Ardle et al.** Describes physique in terms of muscular and non muscular components. The diversity in overall body dimensions can be compared among individuals or groups from that of reference man and reference woman.

The rules of 20th-century competition are quite different from those of ancient times, the spirit of the sport remains true to its early Greek roots. The modern Olympic motto *Citius, Altus, Fortius* (faster, higher, stronger) best captures track & field competition. Each event determines who can run the fastest, who can jump the highest or the longest, or who can throw the farthest.

Track & Field consists of running, hurdling, jumping, and throwing events, held between individuals and teams at indoor and outdoor meets. The running and hurdling competitions make up the track events, while the jumping and throwing contests comprise the field events. In many countries the sport as a whole is called *athletics*.

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The greater size of the throwers in all dimensions contributes to increase the proportionally body weight of these athletes. The stresses of weight bearing in the case of throwers may be responsible for broadening their knee. The better development of the lean body mass will help them to provide the great strength required in the throwing events.

SHOT PUT

Shot put event was including in first Modern Olympic Games (1896) in Athens. The Shot is put from a circle 2.135-meter (7 feet) in diameter. A curved stop board is fixed in the middle of the circumference of the front half of the circle. The shot has to be put from the shoulder with one hand. When the athlete had taken a stance in the ring for starting his put, the shot has to be in the proximity of the chin. One of the earliest forms of shot putting was an event in which a huge erode stone was used as the implement. The stone was "put" as a test of strength among the warriors of peacetime armed forces of the previous century. This form of Shot putting is said to have originated in Scotland. The Scottish war chief's palace gate was mounted on either side with large stones, and all male visitors were

invited into the palace only after they tested their strength by lifting and throwing the huge stone off the gateposts.

The invention of the cannon brought about the use of the cannon ball to replace the older idea of testing one's strength by putting a stone. Since the cannon ball was not made to any regulation size or weight in those days, it continued to remain as sports implement even as late as 1890. It is said that a cannon ball weighted as much as 42 Ibs in Scotland, and because of its great size and weight, it was thrown from the shoulder with the help of both hands. Sports history has traced the use of a 56 Ibs iron ball, which was used by the early Irish settlers in U.S.A. for the same type of two hand throw from the shoulder.

DISCUS THROW:

Discus throwing is said to have its origin from the days of the ancient Greek Games, which date as a back as 1100 BC. In the First Ancient Olympic Games, throwing the "QUOITS" was the original form of the event. The famous statue of Myron's entitled 'Discobalus', depicting a thrower in the act of throwing from a pedestal, has been a historical movement which is often quoted today.

Discus throwing was one of the throwing events included on the program of the first modern Olympic Games in 1896. It was held in the form of a free style throw, which was taken from a 7-ft. circle. The actual method of executing the throw is not very clear, but Robert Garrett, U.S.A. won the 1896 Olympic discus throw, with a distance of 95-ft. $7\frac{1}{2}$ inches.

JAVELIN THROW

The Javelin had originated form the 'spear'. The spear has always been in use as a combative weapon. Tribal people used it for personal protection and for hunting food, and the modern world uses a similar implement today for sports competitions.

Throwing the spear for accuracy and distance is said to be the most earliest from of using it for sports activity. The spear-throwing contest was one of the events in the Ancient Olympic Games. These Games were mainly celebrations of religious festivals in which the soldiers participated as a means of peacetime occupation and fitness.

The first known javelin throw competition was one in which the Javelin was a spear like implement which had a leather thong attached to its balance point on the shaft. The thong was twisted around the wooden shaft and its free end was held by the thrower through a loop in which one finger was inserted and the other fingers gripped the shaft. When the implement was released, the thong produced a very fast spin of the shift by unwinding with a snap. This spin was intended to give the implement good stability in flight and there by a gain in distance.

Javelin throwing was first included as an Olympic Event in the 1908 London; the first Olympic Games winner was Erik Lemming from Sweden with a throw of 175ft 6inches. The run up and throw technique that was used by Lemming as far back as 1906 resembled the technique used by most of the throwers even 30 years later.

HAMMER THROW:

The earliest known information about the hammer throws event dates as far back as the year 2000 BC one of the events held in the ancient

Tailteann Games held in Ireland was the "Roth cleas" or wheel feat". This event involved swinging and throwing the hub and spoke of a chariot wheel for distance. The hub part of the wheel consisted of weight to be throw and the spoke served as a rigid handle which was gripped by both hands to execute the throw.

Years later, the black smith's sledgehammer became the official implement in competitions, replacing the hub and spoke as the implement. The first known sledgehammer throw competition is reported to have been held in the years 1860 AD during the Oxford University sports held in England.

In 1886, an Irishman, J.S. Mitchell, throws the Hammer to a distance of 110 ft. 4 inches. It is reported that the Hammer he used was 16 Ibs in weight and consisted of a wooden handle just like that of a sledge Hammer. The length of the handle was not specified but it was required that the throw had to be made from a 7 ft circle. In 1887, the circle was enlarged to 7 fit 9 inches and in 1896, the handle was changed to a flexible metal attachment instead of a rigid wooden handle. It was in 1907 that the rules finally standardized the throwing circle to be 7 ft. in diameter and Hammer shall consist of a spherical metal head attached with a flexible metal wire or chain attachment with a looped handle.

RECENT DEVELOPMENTS IN THROWING EVENTS:

In modern time various throwing techniques exploiting best the principles of mechanics had evolved, they demand events specific physique and advanced scientific training methods for gaining optimum performance.

Shot put:

Year	Name	Country	Distance	Type of technique use
1908	Ralph Rose	USA	46′7″	45 semi-forward facing shuffle side-step technique
1912	Ralph Rose	USA	90′ 10”	90 side facing hop shift technique (Both hand)
1924	Clarence Houser	USA	49′.2″	90^0 side facing hop shift technique
1934	Jack Torrance	USA	57′.1″	90^0 side facing hop shift technique
1948	Charles fonville	USA	58′.3″	Semi –back facing with shoulder twist starting position using a quick and low side on glide method.
1956	Parry O’ Brien	USA	53′.	Complete back-facing starting position and glide technique, with a rock back onto the heel to initiate the glide
1968	Rady Matson	USA	67′.4″	A modified P. O′ Brien technique in which the glide was executed on the ball of the

				foot without a rock back on the heel
1972	Alexander Bary schnikow	USS	21m	The foist official rotation technique (Disco- put) used in the Olympic Games)
1978	Brien old field	USA	22.12m	Rotation technique similar to A Bray Schinkar of USSR
1979	Udo Bager	G.D.R	22.15m	Used the P. 0. Brien technique with two modifications (a) A two leg support starts position and (b) A short glide ending in a wide delivery stance.

DISCUS THROW

Year	Name	Country	Distance	Type of technique use
1908	Mortin Sheridan	USA	134′2″	90^0 facing position to the throwing direction within a 7 ft. circle in the from of a side step and throw.
1912	ArmsTaipale	Finland	148′4″	The first time from a 2.50m. circle using a single turn and throw technique in which one foot at a time always

				maintained contact with the ground.
1925	Bud Hauser	USA	155′.3″	The first known one-and half turn technique in the "steep" turn style used by Armas Taepaple for one turn.
1930	Eric krenz	USA	167′.2″	The first one and half hop style turn technique in which both feet left the ground in an up and down jump style
1939	Phil Fox,	USA	172′.4″	The first one and half 'pivot' turn technique in which turning speed was the main achievement the pivot was expected low the ground, so that the up-and down hop was not present during 'T' turn.
1946	Bob Fitch	USA	180′.3″	Introduced the running rotation technique which was further improved by Semites and fortur Gordian both of USA in 1953, raising the record

				with this method to 194'.6".s
1956	AlOerternots - Four time Olympic Gold Medals- 1956,1960,1 964& 1968	USA	184'.10"	Improved the running rotation technique of 1½ turns used by Iness & Gordin by introducing a unique forward leaning position of the trunk at the start of the turn and a type of hip twist in the non-support phase.
1968	Jay silvester	USA	224'.5'	The first thrower to introduce an except starting position with a wide sweeping right leg for the start of the turn, ending in a two legged jump release.
1976	Mac. Wilkins	USA	232'.6"	Modified starting method with a 'no reverse' fixed front leg.

JAVELIN THROW

It can be said that there has really not been any dramatic change in the over all execution of Javelin throwing technique since 1906. The only really dramatic incident in the long history of this event was brought about by a Spanish athlete named Miguel Sal Cedo who threw 300ft.in 1956 with a phenomenal Discus type turn and throw method. The IAAF Rule this technique of throwing as illegal because it did not confirm to the established rules.

In recent years, the established Finnish Javelin throwing technique, which was called the front cross style, has changed to a slight degree. Today it is claimed that the cross step as such does not exist any more. In the technique adopted by the world's top Javelin throwers today, the lower body and hip axis continues to face the throwing direction through out the run up and as well as during the delivery stride while the upper body and shoulders axis is twisted backwards in the direction of the extended throwing arm with Javelin. The result is that approach speed and rhythm is maintained and transferred to the implement via the bow-tension torque created by the twist and untwist action of the shoulders in the release is more effective than was possible with the older cross-step style. In the cross step method, the thrower turned the hips along with the shoulders so that both the hip and shoulder axis were parallel to each other, forcing the right leg to actually cross over the supporting left leg before the delivery stance was achieved. The modern technique has been termed as the 'front facing' style rather than the front cross-step' style these days.

HAMMER THROW

One of the most important aspects of the modern concept of Hammer throwing technique analyzed by Soviet Hammer throw expert, Anatoliy Samozvetsov, is the duration in the turns and the path of the Hammer in relation to the thrower and the direction of the throw. The duration of the acceleration phase depends on the landing of the right foot from the single to the double support phase of each turn, and then changing the action from the double support phase to the single support phase in each turn.

By making a detailed film analysis, Samozvetsov arrived at certain conclusions in connection with the technique used by more than 100 world's best throwers in this event. What he found was that the angles of the lift-off and landing of the right foot fluctuated between 31°(degrees). He decided on an arbitrary 65-degree as the line between the early and late lift-off of the right foot, and 250 degrees as the limit between the early and late landing of the right foot. Based on the above mentioned arbitrary angles all throwers can be divided into four technique groups.

1. $23^0 - 30^0$ – Optimum acceleration curve path.
2. $30^0 - 65^0$ – Early lift-off zone of right foot
3. $65^0 - 100^0$ – Late lift-off zone of right foot
4. $217 - 250^0$ – Early landing zone of right foot

$250^0 - 281^0$ – Late landing zone of right foot.

FACTORS INFLUENCING THROWING:

Distance: - (a) Refinement of the movement structure (Technique) is the principle method of increasing the distance of the throw with the whole action as compared to the standing throw effort. The correct

sequence in the summation of muscular forces applied to the implement in order to transmit the optimum speed of release to the implement must start with the larger but slower muscle groups first and this must be followed by the smaller but faster groups of muscles as the implement approaches its maximum speed just before the release.

Shot put – Glide – 1.5m – 2.0 m, Rotation – 2.5 m – 3.0 m

Discus throws –8.0-m – 12.0 m

Hammer Th. – 15.0 m - 22.0 m

Javelin Th. – 25.0 m – 30.0 m

(**B-**) The distance that the implement will travel in flight after it is released is directly related to the following factors:

I The speed of release (V)

II The angle of release (0C)

III The height of release (h)

IV The air resistance (k)

V The force of gravity (g)

Air resistance and its effects will be discussed separately for the Discus and Javelin throw events. The effect of air resistance in Shot putting and Hammer throwing may be neglected in these two events.

The force of gravity is always constant at $9.81 m/s^2$ in both planes upwards as well as downwards and thus creates the basis for a parabolic flight of the implement after its release.

The three most important factors contributing to the distance traveled by the implement is therefore the release speed, the release angle and the release height of the implement.

Release angle/degrees:

Speed of release constant –24 m/s & release height at 2.0m								
Angle (0^0C):	20^0 ↓	25^0 ↑	30^0 ↓	35^0 ↑	40^0 ↓	45^0 ↑	50^0 ↓	55^0 ↑
Dist (M) :	42.60	48.92	54.10	57.89	60.13	60.52	59.42	56.56

The laws of ballistics tell us that in theory the optimum angle of release of the implement is 45^0 degree. This may apply in the throwing events only it the point of landing of the implement is at the same level as the height of its release. In the throwing events, the height of release is between 1.5 m to 2.30 m above the landing area, Hence, the optimum angle of release is not the ideal angle of 45^0 degrees, but necessarily less. It depends on the height of release as well as the speed of release, as also the particular throwing events it self.

Hammer throwing – 44.0^0, Shot rent –40^0 - 42^0

Discus throwing –30.0^0, - 30^0 - 37^0

*.In Discus and Javelin throwing, the optimum angle of release will depend upon the direction of the wind. For head winds the angle will be lower (25-30 degrees) and for a tail winds it may be higher (35-40 degree).

*The aerodynamic shape and surface smoothness of the implement in the Discus and Javelin throw events will permit the implement to remain in flight longer (float).

*The angle of incidence (attack) is positive or negative as compared to the angle of release. Between the angles of 30 to 40 degrees, it can be observed that for the same constant speed of release of 22. m/sec, there is an increase in the distance where there is a negative angle of incidence, with the optimum at 35 degrees at a negative angle of incidence of (–15.0^0) degrees.

Angle of release & angle of incidence (attack): -

The effects of Positive and Negative angles of Incidence on distance						
Release angle	$+10^0$	$+5^0$	0^0	-5^0	-10^0	-15^0
50	-	-	-	49.10	50.30	50.50
45	-	-	48.50	50.50	51.80	52.30
40	49.50	51.10	52.00	52.90	53.60	54.20
35	51.00	52.50	53.80	54.30	55.20	56.40
30	50.00	51.30	52.40	53.70	54.30	54.80
25	-	-	50.80	51.90	53.00	53.60
20	-	-	-	49.60	51.40	52.20

The technical details in the execution of each of the four phases are different in each of the four throwing events.

Phases	**Shot**	**Discus**	**Hammer**	**Javelin**
Preparation	Initial movements	Preliminary swings	Preliminary swings	The approach run
Momentum gaining	The glide or turn	The turns	The turns	The withdrawal and impulse strides
Main phase	The putting action	The release actions	The release actions	The delivery stride and delivery action
End phase	Recovery	Recovery	Recovery	Recovery

SOMATOTYPE:

The term Somatotype is a Greek word, which means "forms of body". Sheldon first used this word Somatotype in 1940, the greater propagation of interest regarding a particular type of physique that provides an athlete with greater performance for a particular games, come up around the middle of twentieth century. Heath Carter explained Somatotype as a description of the present morphological confirmation. It is expressed in a three numeral rating, consisting of three sequential numerals, always recorded in the same manner. Each numeral represents the evaluation of three primary components of physique, which describe individual variations in human morphology and composition.

He gave Somatotyping methods in 1967, Heath Carter method of Somatotyping is one such attempt, which fulfils to major extent these requirements and is widely in use through out the world during last three decades.

It is based on anthropometric measurements, which are easy to take on the subjects. Heath Carter took ten anthropometric measurement for determine Somatotyping viz. height, weight, skin fold of triceps, sub scapular, supraspinal and calf, biepicondylar diameters of humerus and femur, girths of biceps and calf.

Somatotyping looks at how fat, muscular and linear the body is, in that order. Somatotype can describe everyone's body shape. There are three extremes:

Extreme Endomorph

Wide hips and narrow shoulders (pear-shaped)

A lot of fat on the body, upper arms and thighs

Quite slim wrists and ankles

Extreme Mesomorph

Broad shoulders and relatively narrow hips (wedge-shaped)

Muscular body

Strong forearms and thighs

Very little body fat

Extreme Ectomorph

Narrow shoulders, hips and chest

Thin face, high forehead

Thin legs and arms

Very little muscle or fat

Everyone is a mixture of all three basic body types, with ratings such as 3 4 4 or 352.

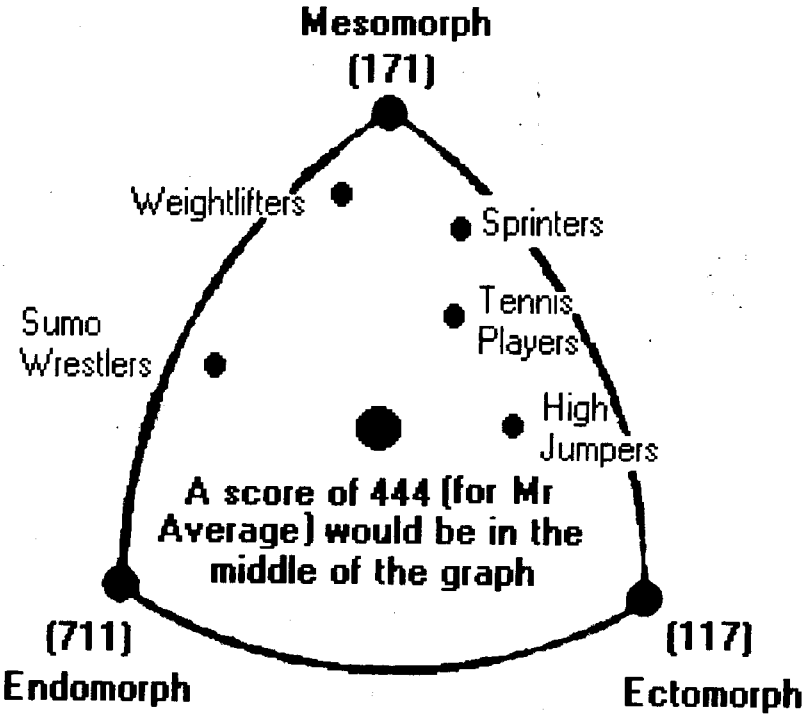


Figure-1

BODY COMPOSITION:

The body composition studies have been conducted very extensively on the athletes. The body can be divided into several compartments according to definable tissues. A two component model used commonly divides the body into a fat portion, and further divides the fat–free mass into skeleton, muscle and the remainder. The fluids etcetera can also be studied in terms of total body water, extra-cellular water, intra-cellular water, total body potassium, calcium, sodium and so on. However, the athletes have mostly been studied considering the body either as two or four compartment model.

The science of body composition is an important moroho-physiological characteristic. The proportions of these components are different in males and females. Its relative development is dependent on the environmental influences, sex, socio-economic conditions, occupation, genetics, nutrition and exercise.

Mc Ardle et al. pointed out that athletes generally have physique characteristics unique to their specific sports. For example field event athletes have relatively large quantities of lean tissues and a high percentage of body fat whereas long distance runners have the least amount of lean tissue and fat mass. He also pointed out that football players are amongst the heaviest and leanest of all sports men. **Lohman** pointed out the errors involved in determining the body composition in children and youth prior to their age of chemical maturity. The fat free mass (FFM) is not stable in growing children and youths because water content decreases and body solids (bone density) increases in concentration until maturity.

BODY PROPORTIONALITY:

The relationship of length to breadth, height to thickness, length-to-length etc. of various parts of body represents proportions. This importance of proportion becomes evident, when we want to compare particular body parts of two persons who are otherwise different in over all size. The proportions or ratio keeps one measurement constant in all subjects compared and evaluate the differences in the other measurements. The body proportion can be studied in various ways, but indices method is best for determining body proportions.

The general physical fitness of top ranking athletes has been evaluated. Proposals are coming up for the selection of potential athlete with the designs of tests and the body size predictions. Human growth and performance is also an important field in this regard. **DeGaray et al.** and **Klissoras** have worked out the genetic aspect of performance.

The physiological factors limiting one's performance in sports are also well known. It is the understanding of interaction of all these factors that helps in designing the way for selecting the children for appropriate game. The author desires a scientific basis of selection of athletes and sportsmen. One may not take it guaranteed that every child can be trained to be an Olympian, for there are a few persons who have a combination of the development of each requisite factor of the highest degree. The idea is to put the interested individual in a game or event in such a way so that he gives out the best of his abilities.

The purpose of this research work is to place the role of anthropometrical variables on the performance of Indian male throwers. The study is also attempting to evaluate the difference existing in anthropometrical profile of throwers engaged in different throwing events.

STATEMENT OF THE PROBLEM

After reviewing the related literature and the objectives of the study the researcher had stated the problem as:

"Comparative study of anthropometrical characteristics of Indian elite male throwers of different throwing events"

HYPOTHESIS

It is hypothesized that significant differences will be observed in the anthropometrical characteristics of throwers engaged in different throwing events.

DELIMITATION

In light of resources available the study is delimited to-

Elite male throwers- Twenty five each elite male throwers of Shot Put, Discus, Javelin and Hammer were Selected from National, International Tournaments and India camp, S.A.I. and State Hostels.

Selected anthropometrical Parameters:

***Stature** –Distance from vertex to ground

***Weight-** Nude body weight

***Sitting height** - Distance from vertex to stool

***Chest girth-** Circumference of chest at nipple line

***Chest depth-** Distance from anteriorl to posteriorl level of mesosternal point.

***Femur Biepicondylar diameter** –Distance between medial and lateral epicondylor of the femur.

***Humerus Biepicondylar diameter-** Distance between medial and lateral epicondylar of the humerus.

***Hips breadth** –Distance between right and left Superior border of the iliac crests.

***Shoulder breadth** - Distance from right acromion to left acromion.

***Upper arm length-** Distance from inferior border of the acromion process to radiale.

***Lower arms length-** Distance from radial to stylion.

***Total arm length-** Distance from acromion to dactylion.

***Upper leg length** - Distance from trochanterion to tibiale lateral.

***Lower leg length** - Distance from tibiale medial to sphyrion tibiale.

***Total leg length** - Distance from trochanterion to pternion.

***Biceps muscle girth** – Maximum girth of the flexed biceps

***Calf muscle girth-** Maximum circumference of the calf muscle

***Thighs muscle girth-** Maximum circumference below the gluteus furrow

* **Triceps skin fold-** Mid acromiale-radiale line.

***Sub scapular skin fold**-Below the right scapula

***Supraillic Skin fold-** Above the anterior superior iliac spine

***Thigh Skin fold** – Anterior surface of mid inguinal point

***Calf Skin fold-** Medial side of the calf.

***Foot Length-** Distance from acropodion to pternion

Somatotype: (Heath Carter method, 1984).

Endomorphy: -

$-0.7182+0.1451 \times {}^*\sum SF - 0.00068 \times {}^*\sum SF^2 + 0.0000014 \times {}^*\sum SF^3$

[Where SF= sum of triceps, sub scapular and supraillic skin fold multiplied by 170.18/height in centimeter]

Mesomorphy

0.858 × humerus breadth + 0.601 × femur breadth + 0.188 × *Corrected arm girth + 0.161 × *Corrected calf girth–height×0.131+4.5

(* Subtract the triceps skin fold and calfskin fold from the arm girth and calf girth respectively).

Ectomorphy: - The Ectomorphy was determined by comparing the calculated height, weight ratio (HWR) of the subject with the underline values given below.

$$HWR = \frac{\text{Height in cm.}}{\sqrt[3]{\text{Weight in kg}}}$$

If HWR is greater than or equal to 40.75 than ectomorphy

= 0.732*HWR-28.58

If HWR is less than 40.75 and greater than 38.25 then ectomorphy

= 0.463*HWR-17.68

If HWR is equal to or less than 38.25 than ectomorphy = 0.1

*** Body composition:**

Body fat (%) = 0.43 (A) + 0.58 (B) + 1.47

A = Triceps fat fold (mm)

B = Sub scapula fat fold (mm)

***Body proportionality:**

Body indices:

Sitting height –stature index

Ponderal index

Thigh length –lower leg length index

Upper arm length-lower arm length index

Hips breadth-stature index.

Shoulder breadth – stature index

SIGNIFICANCE OF THE STUDY

Proposals are coming up for the selection of potential athlete with the designs of tests and the body size predictions. The physiological factors limiting one's performance in sports are also well known. It is the understanding of interaction of all these factors which help in designing the way in selecting the children for appropriate game and training. The author has put forward an idea of scientific basis of selection of athletes and sportsmen. One may not take it guaranteed that every child can be trained to be an Olympian, for there are a few persons who have a combination of the development of each requisite factor of the highest degree. The idea is to put the interested individual in a game or event in such a way so that he gives out the best of his abilities.

Thus the findings of this study are going to have theoretical as well as practical implications. It shall highlight anthropometrical traits of elite male throwers of different throwing events, which in turn shall provide guidelines to our coaches, physical education teachers and sports scientists to select appropriate talent at an early age, as early childhood is the best period for the development of neuromuscular co-ordination of various skills. This may help in fulfilling our dream of producing world-class throwers.

Chapter –II

Review Of Literature

REVIEW OF LITERATURE

The Researcher had undergone a vast survey of related literature. He had appraised various journals, books periodicals etc. related with various aspects of this study. The important studies having specific relevance with the undertaken study are cited below.

Sodhi & Sidhu In (1991) found D.,H., S. (Discus Hammer and Shot put) throwers to be significantly taller (182.4cm) and heavier (88kg) than all other field event athletes. On the other Javelin throwers are the shortest (172.3cm) but the L.H., T. (Long, High, Triple) jumpers have the least weight (60.8kg). The athletes of L.H. & T-group are significantly taller than the controls, but pole-vaulters and D. H. & S. throwers are both significantly taller and heavier than the latter. The Javelin throwers, on the other hand, do not show any appreciable difference in stature but in weight they are significantly heavier than the controls. Almost similar results have been obtained on the athletes of Olympic field events. However, their fellow Javelin throwers were taller than the jumpers.

The throwers in D.H.& S. group have the largest sitting height, biacramial diameter, bicristal breadth, and chest circumference than those of the controls and all other groups of athletes. Most of these measurements are significantly, greater at 5% level. The Javelin throwers and pole-vaulters do not show much difference in trunk measurements. The category of jumpers (L.H.&T.) have evidently smaller trunk diameters than those of throwers, except the bicristal breadth which is 0.7 cm shorter in the case of Javelin throwers.

Like the stature and track measurements, the D.,H., & S. throwers are found to have larger upper extremities among the athletes of all track and field events. On the other hand, the Javelin throwers have the smallest

length of limbs and the L.H. & T. Jumper have least circumference of upper arm among the athletes of field events. The pole-vaulters dominate the L.H.&T. Jumpers and Javelin throwers in the measurement of upper extremity length.

The S.,D.,H. throwers, who have the largest trunk and upper extremity measurements, approximate the L.,H.&T. group in the lower extremity length. The Javelin throwers have been found to have significantly the least average values of lower extremity length in this group of field athletes. However, among them the circumferences are significantly largest in the case of D.,H.&.S. throwers and smallest in the case of L.,H.,T. jumpers.

The hip breadth is more developed in relation to stature in the throwers of D.,H.& S. group. However, the L.,H.&T. jumpers are more slender in this respect. The relationship of the chest circumference with stature is variable among the field athletes. It is again in the D.,H.&S. group that the athletes have a proportionately larger thoracic region, but the L.,H.&T. jumpers are most slender in this respect.

Tanner in (1964) observed discus, Javelin and Hammer throwers and Shot putter to somatotype around 3-6-2 or 3.5-6-2. The track athletes and the Jumpers, on the other hand, had Somatotype mostly ranging between 2-5-3 and 2-4-3-5. Among the runners, there was a clear difference between sprinters and others. The average Somatotype of the sprinters was 2.5-5.5-3, of the 400m runners, 2.5-4.5-4 and of the 1500m, 5000m and marathon 2.5-4-4.

Mokha R and L.S. Sidhu, (1988) carried out a study on Indian athletes of different levels of competition. Six skin fold measurements (Biceps, triceps, forearm, subscapular, supraillic, calf) were made on 157 track and field athletes (42 throwers 35 jumpers, 80 runners) the range of ability of the athletes ranged from state (highest level) through Intervarsity to district (lowest level) 81 subject acted as controls. Total body fat was calculated by the formula of Durnin & Womersly (1974) it was found that the throwers significantly had more fat of all the six measurement parameters than the jumpers & runners. The jumpers & runners did not differ much from each other. With the increasing levels of competition, tend of increasing in fat was observed in throwers & a decrease in jumpers & runners.

H.S. Sodhi in (1991) concluded Discus, Hammer and Shot putter to be taller, heavier and posses longer extremities and broader knees with a larger amount of lean body mass. As already mentioned their greater weight is useful, because when the object is thrown forwards and upwards, an equal and opposite reactive force is exerted on the athlete, pushing him backwards and down wards. The effect of this reaction is however, more if he is lighter. The greater height in their case will be of further advantage by making the flight of the implement longer before it touches the ground. Further while throwing the Discus, speed of the Discus at the moment of release is of prime importance in determining how far it will go and for a given angular velocity, the speed is proportional to the length of the 'lever' throwing the Discus from the axis of the thrower hence the desirability of long as well as powerful arms. The greater size of the throwers in all dimensions contributes to increase the proportionate body weight of these athletes. The stresses of weight

bearing in the case of the throwers may be responsible for broadening their knees. The better development of the lean body mass will help them to provide the great strength required in the throwing events.

Carter in (1970) observed that the throwers of Discus, Shot, Javelin and Hammer differed greatly in physique from the other athletes. As group, they were taller and heavier with longer arms in relation to their legs. They had broader shoulders and broader hips even for their trunk size, and were somewhat fatter than the track athletes. Their proportions of legs to the trunk were similar to those of middle distance runners.
The Shot putters were also very large and muscular men. None was under 185 cm and the tallest shot putter was 195 cm and weighted 115kg. They also had long arms, but not so long as those of the Discus throwers. Like the Discus throwers, they had wide humerus in relation to the breadths of the femur and tibia. The large arm bone was not seen in Javelin and Hammer throwers or in the sample of weight lifters.

Cureton (1951) studied 22 track and field champion athletes of the United States and reported typical track men to be slight in skeletal framework with longer forelegs relative to thighs and longer legs relative to the length of the trunk, but were exceeding well muscled. The Jumpers, hurdlers and vaulters were relatively slim in skeletal build and were typically taller with longer legs and shorter trunks. The shoulder width/Bi-iliac hip width index was shown to be important for differentiating Javelin throwers and gymnasts from other types of athletes. The typical throwers (including Shot putters) were those with greater arm span/height and greater upper arm length/ forearm length. The jumper's hurdlers and vaulters had relatively great leg length/trunk length and relatively large foreleg length/ thigh length. The success of athletic champions is not fully

explained by inherent anthropological body type measurements, because among men of approximately the same physical type, there are great differences in performance. Developing the proper skill takes many years of patient training of the muscular system.

Parnell (1951) worked on university athletic club athletes and found all groups of Athletes taller then the controls. Of the athletes, the Javelin throwers, Discus throwers and Shot putters were tallest and sprinters shortest. With regard to the mean weight, middle and long distance runners were the lightest athletes though not lighter than the control group. All other types of athletes had the mean weight above that of the controls. The reciprocal of ponderal index was found to be lowest among heavy event athletes who also registered a small range. The highest value of this index was in the case of the long distance runners, with an average build equal to that of the control series. In comparing sprinters with the controls it had been noticed that especially the 100-yard sprinters were distinguished by a heavier physique and by being more muscular than the average. For long distance runners, the value of reciprocal of Ponderal index higher than 13.6 may indicate that the weight of musculature is too slight for this task. Subischical length was shortest among the controls, slightly greater in sprinters, greater still in long distance runners, High jumpers and Hurdlers and greatest in the small group competing with Discus, Javelin and Shot. The conclusion was reached that an individual's choice of athletic events might be recognized in greater degree, to be because of the characteristics probably inborn than those recognized previously.

Telka and his Associates (1951) studied 245 Finish top ranking track and field athletes and wrestlers. They did not find any appreciable differences in respect of constitution among the athlete of different branches, except in certain extreme groups. However, they found them different from the control sample. They stated; according to that material body build of a definite type did not appear to be a necessary prerequisite to the achievement of good athletic results. However during 1954, the same workers again reported the top- ranking track and field athletes and related various body measurements to performance. Throwers were tallest in this material and they seemed also to benefit most from their height. The correlation between the relative shoulder breadth (with stature) and performance was significant in throwers and long distance runners. The correlation between the relative shoulder breadth (with stature) and performance was negative and highly significant in the case of the throwers. The correlation between the relative chest circumference (with stature) and performance was negative and highly significant in the case of sprinters and positive and significant in case of throwers.

Malhotra et. al. (1972) studied the functional capacity and body composition of the throwers, Jumpers, sprinters and the middle and long distance runners. The track men and jumpers were found to have a higher lean body mass with less fat content than the throwers who were tall and heavily built. The middle and long distance runners had highest and the throwers, the lowest maximum O^2 intake capacity values in terms of body weight and lean body mass. Similarly, the track men had lower maximum heart rate than the other group of athletes. The jumpers and throwers had stronger muscle power, however, the later were stronger in arm and shoulder muscle strength too.

Muthiah & Venketswarlu (1973) studied the Indian track & field athletes and noticed the throwers to be heavier, taller and older than other athletes. Among runners, the age increased and the height and weight decreased with the increase in the distances, they run. The jumpers and hurdlers were taller and heavier than sprinters, but were shorter and lighter than throwers. The decathletes were the second heaviest, they were all rounders.

Sidhu and Wadhan in (1974) worked on throwers, who were found to be heavy and tall with relatively large limb circumferences and bicondylar diameters. They had better developed lean tissue in the limbs associated with greater amount of fatty tissue.

Sidhu et al. (1975) took the upper roentgenogramms and some anthropomentric measurements of 22 throwers and compared them with 45 normal non-athletes. The throwers were found to be significantly taller and heavier with bulkier builds of larger circumferential measurements and skeletal measurements. Their lean body mass was greater than that of the control sample. Roentgenorammetric assessment displayed that the constant throwing exercise had resulted in greater development of the upper arm muscles, especially the triceps.

Hirata (1966) reported data in respect of the participants of Rome, Tokyo, Munich and Montreal Olympic with respect to different games and events. Among athletes, the short and middle distance runners and jumpers were, as a whole, younger, but the long distance runners and throwers were older. These data indicated that the participants in events which need great muscular strength reached the climax in the early period, whereas the participants in events, which needed much endurance or technique, had delayed climax, which continued longer.

Kohlrausch in (1929) studied the athletes who participated in the 1928 Olympic Games at Amsterdam, and arranged all his athletes into fifteen different groups, but these again could be grouped into three major classes:

Slender types: - These include runners, Jumpers hurdlers, with relatively long legs and slender bodies.

Medium types: - These include decathlon and Pentathlon athletes, boxers, ball- players and swimmers.

Massive Types: These include weight-throwers, weight lifters and up to point gymnasts.

Arnold (1931) reviewed studied of various workers and concluded three main types. gymnastic types with relatively long bulk, coupled with breadth.

Wrestler types with mighty forms, great breadth of shoulders and Pelvis coupled with great breadth and depth of chest. Pentathlon types-with medium to slender bodies, relatively long legs and less breadth.

Krakower (1935) Reported on 16 high Jumpers and found that the type of the individual that succeeded in high jump had long legs, a short body and broad feet.

Vujovic d. and lozovina v. (1999) examined the differences between two groups of elite athletes' anthropometric measurements. The groups were from sports of water polo and rowing. Subjects were measured with set of 18 anthropometric measurements. Multivariate analyses on manifested measurements as well as on scores on latent dimensions were employed to analyze the difference between the groups. Differences were based on differences in measurements. Which can be attributed to muscle tissues and fat tissues, which were both in favour of

water polo players. There were no differences in measurements of skeleton except for the measurements of bicristal width and leg length. Different training procedures and different surrounding in which activities were taking place cause the differences. No differences in skeleton measurements,were the consequence of the selection process.

Heaths Carter in (1982) found athletes who wish to achieve success in sports at a high level can compare their physique with those of Olympic athletes. If the athlete is within the limits of the Olympians, then the appropriate structure for high performance is achieved. Consideration can then be given to whether changes in physique, such as lower body fat or increased muscles mass would enhance or hinder his performance. This problem is of special significance in games like weight lifting boxing, judo and wrestling which are competed on the basis of body weight. In these games, the competitors are required to compete within their respective weight categories. Out of many measures of physique, the stature being of most common interest, has been thoroughly investigated. It has already been mentioned that in same sports greater height is an advantage. Whilst in others, shorter stature is preferable. All these studies are based on adult athletes who in most cases are a product of many years of training starting from childhood.

Kroll (1954) conducted a study on somatotype of 36 wrestlers from universities in mid western United States. Where the mean Somatotype of his subjects was 2.7-5.0-3.8, mean height was 174.8 cm, mean weight was 73.1 kg while height weight ratio was 12.87. The wrestler had longer upper extremities, longer trunk and shorter lower extremities, which bring down the center of gravity and thus help in increasing stability

Singh S.P. and Malhotra P. (1986) conducted a study on Indian National cyclists. Anthropometric measurements were taken on 34 male and 9 female Indian cyclists who were attending a national coaching camp at Patialia with a view to evaluate their body composition, morphology and Somatotype. The measurements were taken in the morning to avoid any possible effects of fatigue on height and other body dimensions. Body fat was calculated from skin folds using the formula devised by Durnin and Womerslay (1974) and Somatotype was assessed using the Heath and Carter (1967) method. The male and female cyclists were significantly heavier and possessed greater limb girths and skeletal diameters than their control counterparts. The percentage of body fat was similar in female cyclists and controls. The cyclists showed a greater development of musculo-skeletal tissue of the lower extremity relative to height than controls. The Somatotype of male and female cyclists were 2.76-3.90-3.21 and 5.17-3.22-2.56, respectively. Compared to the control groups, the cyclists of both sexes were more mesomorphic and stocky. Since the maximum share of the power transfer to the pedals is that of the lower extremities, therefore, highly developed muscles of calf, thigh, buttocks and hips of the cyclist seem to have a definite advantage.

Keogh j.w.l. et al. (2000) carried out a study to assess the performance of senior female field hockey players (both regional representatives and amateurs) on a number of physical fitness, anthropometric and hockey-related skill tests. Physiological tests included 10m and 40m sprint, 6x40m repeated sprint test (5), multistage aerobic test, standing long jump, agility test, body mass, height and sum of four skin folds. Skill levels were assessed using pushing power, as well as dribbling and accuracy tests. Results showed that differences in a number

of measurements occurred between the two groups. No differences were found on performance measurement between subjects in the follicular or lateral stage of the measurement cycle. The present study demonstrated that both physical characteristics and technical skill were important components of performance in senior female hockey players.

Medved (1966) Studied the height and weight of sportsmen and sportswomen in a city. The greatest deviations, regarding height in the positive sense were observed in basketball players, volleyball players and swimmers, whereas wrestlers, boxers and figure skaters were among the sportsmen showing deviations in height in the negative sense.

Sidhu and Anand (1971) Studied 42 athletes and 46 non-athletes in which the former were found to be taller and heavier than the later. The non-athletes were seen to possess higher amounts of subcutaneous fat than the athletes.

Wood R.J. et al. (2000) compared initial field test results of indigenous and non indigenous Northern Territory Institute of Sport (NTIS) AFL squad players. The indigenous players were significantly shorter and tended to be lighter. They were also significantly faster over 40m, due to better acceleration, which supports the sterotype. Other measurements of anaerobic and aerobic power were not different. Further analysis showed the six regional based indigenous players achieved lower scores of fitness than their city-based counterparts. Analysis of playing positions showed a greater representation of indigenous players along the centerline. While there were more nonindiganous players in key field positions, the track and along the half lines. Positional segregation has also been founded in Rugby Leogue (Hallinan 1991). The positional

differences may relate to the body size requirements for each position. While skill and agility were not measured, the smaller and lighter indigenous players may require greater agility and skill levels to compare with larger non-indigenous players.

In a study conducted by **Ambegaonkar and Dikshit** (1964), on 27 Indian Hockey players, the mean age, height and weight were found to be 24.5 years, 174.1 cm and 60.8 kg respectively.

Orvanova E; (1990) conducted a study to find out the differences in body structure between young and adult weight lifter in ten weight classes, and between weight lifters and non-athletes. Weight lifters in younger age groups differed from the adult one in the parameter, which were correlated with performance results. Weight lifter differed from non-athletes according to weight classes. In lower weight classes, lifter had smaller height, shorter length and widths measurements and the values increased with weight classes. But weight lifters in all weight classes had shorter thighs and forearms and greater arm girths. The length of thighs and forearms can be used as important factors for talent selection.

Bemies (1900) reported the results of the study of five outstanding track athletes. The runners and jumpers were found to be 2″ above average in height and with the arm reach an inch longer, with longer legs and also with the lower leg than other persons of the same height. The calf and thighs averaged smaller and the hips an inch narrower. He suggested that these leg proportions gave a quick-acting upper leg a long reach with the lower.

Pere et al. (1954) studied the top ranking track and field athletes and related their various body measurements to their performance. Throwers were tallest in this material and they seemed also to benefit

most from their height. The correlation between the relative upper limb length and performance was significant in throwers and long distance runners. The correlation between the relative shoulder breadth and performance was negative and highly significant in the case of throwers. The correlation between the relative chest circumference and performance was negative and highly significant in the case of sprinters and positive and significant in case of throwers.

Carter (1970) noted 34 white Olympic runners rated by Heath and found all runners uniformly low in the first component. The 800/1500m runners were half a unit higher on Mesomorphy then 5000/10000m runners and marathon runners, whereas the 5000/10000m were half a unit higher on the third component then the other two groups. In his review of Somatotype of athletes, he found the San Diego State and high School runners higher on endomorphy, lower on mesomorphy and slightly higher on ectomorphy than Olympic runners. Olympic runners were 26 year old, but were smaller and lighter than the San Diego runners. The high school runners were shortest and lightest. Apparently, somatotype is a selective factor in distance running at the high school level. Because fat is obviously a handicap in running, the low first- component ratings are not unexpected. The relatively wide range on the second and third components means that more people of suitable height and weight can achieve success at one of the distance runs.

Lewis (1966) studied the Somatotype of 'A grade' provincial representatives and national representative basketball players in New Zealand and found that the heights and weights of players at different levels of selection did not differ, nor did the Somatotype rating, except for a decrease in Endomorphy by half a unit at the higher levels of selection.

Hirata (1966) Studied 186 Tokyo Olympic Basketball players who averaged 189.4 cm in height and 84.3 kg in weight. Except the shot putters, they were found to be tallest in his sample of different games, the tallest of the players being 218cm. And lean type was particularly suitable for prompt action, so they had the most suitable physique.

Morris (1960) studied the structural and physical differences between women athletes and unselected college women. Significant differences were found between all strength tests, vital capacity, height, mesomorphy and ectomorphy. There was clear evidence that the total strength and leg length per pound of body weight were important factors in performance than the body weight and strength alone.

De. Garay et al. (1974) conducted a comprehensive study on the Mexico Olympians. Their entire track group had similar Somatotype distributions and were concentrated mainly in the ectomesomorphic category, sixty one percent of their throwers were endomesomorphs the remainders being dominant mesomorphic. On the other hand, the jumpers. Vaulters and decathlon athletes had no dominant endomesomorphy.

The throwers of Mexico Olympic were considerably heavier than the other group of field events. The former had significantly broader shoulders and longer trunk than the latter. The hips of jumpers were narrower than the throwers. Their legs were found to be longer than the javelin throwers.

Westlake (1967) divided 61 female track and field athletes of San Diego Country into four groups on the basis of there best event and somatotyped them using the Heath-Carter (1967) anthropometric method. The mean Somatotype for each group were sprinters 3-3.5-4, jumpers 3-3-4.5, distance runners 3-4-3.5 and throwers 5-4.5-2. Throwers differed

from the other groups in being heavier, more endomorphic more mesomorphic and less ectomorphic. Distance runners were shortest and they were less linear than sprinters and jumpers. High endomorphy and mesomorphy seemed to be assets to throwers, as with male throwers the body mass was important.

Eiben (1972) observed women throwers to be very tall, heavy and muscular. Their longer trunk was accompanied with longer lower extremities. Their upper extremities were only slightly longer than the average of all the women athletes. They excelled with a marked width development, especially at the shoulder. The shot putters had the most muscular extremities among all the women athletes.

The women Discus throwers were the tallest and the heaviest among all the women athletes. Similarly, lengths of their trunk and lower extremities were the greatest. Their lower legs were relatively long and their thighs relatively short. Their upper extremities were long and strong. Characteristically they displayed the longest span with a well-developed shoulder. The muscles of their extremities were highly developed.

The women Javelin throwers weighted least among all the women throwers. They were scarcely taller than the shot putters. As compared with the other women throwers, the development of their width and that of the muscles of their extremities was moderate.

Amar (1920) pointed out that people of small stature were relatively strong as compared with the tall ones and quicker because the weight decreases in proportion to the cube of the size, whereas the force decreases in proportion to the square of the size, being approximately proportional to the cross-section of the muscles. Short heavy-set people are remarkably strong and make good weight lifters, carters and heavy

laborers. The "grasshopper" types with relatively long legs make good jumper, runners vaulter, hurdlers, and agility athletes.

Bramwell & Ellis (1931) worked on 28 marathon runners and compared them with other Olympic athletes. They were found to be older men in the late twenties or in the early thirties, with lighter build and lower resting pulse, and rather higher systolic blood pressure.

J. De rider et. al. (1998) carried out a study on world-class female African athletes. Data were collected on 178 female athletes with a mean age of 21.7 years. The athletes were from 18 countries with Zimbabwe (n = 45), South Africa (n = 38), Namibia (n = 25), Botswana (n = 24) and Zaire (n = 10). The majority of the subjects were black (65.7%) with Caucasians (29.8%) the second largest group. Females from 11 different sports were measured with track and field (n = 52), netball (n = 48), swimming (n = 15) and handball (n = 14). The anthropometrical variables and techniques selected were primarily those described in Carter and Ackland (1994). Data analysis was performed using (Stat Soft, Inc. 1984-1996). Heath – Carter somatotypes were calculated using equations in Carter and Heath (1990). Endomorphy was calculated with a height correction. Results indicate that the average Somatotype for the female athletes (n = 178) was 3.3-3.6-2.8, that was a central Somatotype with slightly more mesomorphy and Endomorphy than ectomorphy. The four-Somatotype categories, to the left of center on the somato-chart (in which endomorphy and mesomorphy combinations were high and ectomorphy was low) accounted for 40.5% of all female athletes. Another 33.1% were in the central and balanced mesomorphy categories, and 26.4% were to

the right of the center in ecto-mesomorphy through balanced mesomorphy categories. Finally, none of the female athletes were in the lower sector of the somato-chart where mesomorphy was lower than both endomorphy and ectomorphy. Somatotype comparisons were made of female athletes in each of the 11 sports by event or by playing position and performance level. Differences in somatotypes were found between events or positions within sport categories. There were for example significant differences between track and field athletes in the 9 different events in the endomorphic ($F = 7.19$; $p< 05$), the mesomorphic ($F = 5.42$; $p< 0.5$) as well as the ectomorphic ($F = 4.10$; $p< 05$) components.

M. S. Chauhan (2003) carried out a study on prediction of performance of university level throwers in relation to their anthropometrical measurements. The findings of that study lead him to certain conclusions. Age, body weight, height, sitting height, trunk length, leg length, fore-leg length, thigh length, total arm length, upper and fore-arm length, all have positive and significant correlation with performance of university level throwers. The circumferences i.e. shoulder chest, abdomen, hip, arm and thigh circumferences have significant and positive correlation with the throwing performance. Biacromial, bicristal and elbow diameters possess positive and significant correlation with the performance in throwing event. Among skin fold measurements, biceps, sub scapular, Suprailiac and calfskin folds have positive and significant correlation with performance in throwing event. Body density and lean body mass have negative and significant but fat percentage and fat weight had positive and significant correlation with throwing performance. Multiple correlation of body weight, height and total arm length collectively has significant correlation with the throwing performance.

The size of multiple correlation is quite sufficient and hence the regression equation can be used for the prediction of throwing performance of university level throwers.

Sheldon (1940) Evolved a method for classification of human physique based on a system of three component scale analysis by reference to the development of the three embryonic layers – endoderm, mesoderm and ectoderm. The method is known as Somatotyping. Subsequently, various researchers have tried to modify this method to make it more simple and reliable.

Tappen (1950) took Somatotype photographs of 43 of the 57 entrants for the 1947 National Amateur Athletic Union (AAU) weight-lifting championship and these were somatotyped by Sheldon and Krogman. Outstanding lifters in all weight classes were measured and had a mean Somatotype 3-6.5-1. These competitors were characterized by very high mesomorphic and low ectomorphic ratings. The ranges of these components were also narrow. On endomorphy, the range was greater, but still low at 3.5 units.

Dyson (1963) has propounded that while throwing the discus, the speed of the discus at the moment of release is of prime importance in determining how far it will go, and for given angular velocity (dependent on how fast the thrower does his turn) the speed is proportional to the length of 'lever' throwing the discus, i.e. to the distance of the discus from the axis of the thrower; hence the desirability of having long and powerful arms.

Parvez Shamim (2002) Carried out a study to ascertain the difference between physical and physiological characteristics of high and

low performance basketball players and found that the high performance basketball players had greater weight, height, sitting height, femur biepicondylar, humerus bi- epicondylar, shoulder breadth, hip breadth, upper arm length, thigh length, lower leg length, biceps muscle girth, calf muscle girth and hip breadth – stature index than low performance basketball players. High performance basketball players had more mesomorphic – ectomorphic rating and have better segmental proportionality than low performance basketball players. There was insignificant difference in Ponderal index, thigh length – lower leg length index, upper arm length – lower leg length index and shoulder breadth – stature index of high and low performance basketball players. High performance basketball players had lower heart rate and greater vital capacity than low performance basketball players. However there was no significant difference in systolic and diastolic blood pressure of high and low performance basketball players.

Mohd. Khalid khan (2005) Carried out a study to ascertain the differences between high and low performance volleyball players in relation to their Anthropometrical and physiological variables and found that the selected National or high level performance volleyball players were taller, heavier in proportion to stature, broader shoulder, wider hip, longer upper and lower extremities then the low performance volleyball players. They had lesser rating of endomorphic and mesomorphic components but a higher rating of ectomorphic component. The fat free mass was also greater in the high performance volleyball players.

Gerhardt Schmolinsky (1983) pointed out that movement in field throws serve to throw or put the implement over as long a distance as possible. In doing this athlete must observe physical laws (e.g. biological and mechanical laws) and general regulations laid down in the International competition rules. Hence the athlete's performance depends on his ability to tackle environmental factors and on his knowledge of their inherent laws. The better he is familiar with them, the more his movements will be properly directed and efficient.

During the first section the body and the implement are accelerated together and move with the same velocity. The distance between body and implement obtained during the preparation phase should be maintained or only slightly reduced. After this phase the body outpaces the implement and there is at most a slight acceleration. The thrower should therefore strive to keep this section as short as possible. In the shot put, for example, the speed drops to some 0.4m/s during the gliding phase.

After reviewing the literature one reaches to the conclusion that all the sports researchers of the world are engaged in specific research aiming to enhance the sports performance. Either it is anthropometrical or any other sports science field, the aim is to generate some ideas and principles, which must be helpful for breaking the existing barriers of sports performance. The present study is a step in this direction.

Chapter –III

Procedure

PROCEDURE

This chapter contains the methods employed for selecting the subjects, tools and techniques used for collecting the relevant data and statistical procedures applied for its analysis.

SELECTION OF SUBJECTS: For the purpose of this study 25 elite male throwers for each Javelin, Shot put, Discus and Hammer throws were selected from various National and Inter-National tournaments, State and SAI hostels and India camp.

Anthropometrical measurement from 25 Elite male shot putters were collected from:

- Eight- Shot putters from All India Police Athletic championship, Kolkata date. 20-11-2004
- Two Shot putters from SAI Hostel Kolkata, dated- 23-11-2004.
- Five Shot putters from Delhi SAI Hostel, dated 11-03-2005.
- Two Shot putters from SAI Hostel Patiala, dated 27-01-2005.
- Three Shot putters from India camp, dated- 05-02-2005.
- Two Shot putters from State Hostel Allahabad, dated-27-12-2004.
- One Shot putter from Indo-Pak Punjab competition, dated -18-02-2005.
- Two Shot putters from State Hostel Lucknow, dated- 30-12-2004.

Anthropometrical measurement from 25 Elite male Discus thrower were Collected from:

- Seven Discus throwers from All India Police Athletic championship, Kolkata, dated- 20-11-2004
- Two Discus throwers from SAI Hostel Kolkata, dated -23-11-2004.
- Five Discus throwers from Delhi SAI Hostel, dated 11-03-2005.
- Three Discus throwers from SAI Hostel Patiala, dated 27-01-2005.

- Four Discus throwers from India camp, dated- 05-02-2005.
- Two Discus throwers from State Hostel Allahabad, dated-27-12-2004.
- One Discus thrower from State Hostel Lucknow, dated- 30-12-2004.
- One Discus thrower from Indo-Pak Punjab competition, dated-18-02-2005.

Anthropometrical measurement from 25 Elite male Javelin thrower were collected from:

- Eight Javelin throwers from All India Police Athletic championship, Kolkata, dated- 20-11-2004
- Three Javelin throwers from SAI Hostel Kolkata, dated -23-11-2004.
- Three Javelin throwers from Delhi SAI Hostel, dated 11-03-2005
- Four Javelin throwers from SAI Hostel Patiala, dated 27-01-2005.
- Three Javelin throwers from India camp, dated- 05-02-2005.
- Two Javelin throwers from State Hostel Allahabad, dated-27-12-2004.
- Two Javelin throwers from State Hostel Lucknow, dated- 30-12-2004.

Anthropometrical measurement from 25 Elite male Hammer thrower were collected from:

- Seven Hammer throwers from All India Police Athletic championship, Kolkata, dated- 20-11-2004
- One Hammer thrower from SAI Hostel Kolkata, dated -23-11-2004.
- Three- Hammer throwers from Delhi SAI Hostel, dated 11-03-2005.
- Three Hammer throwers from SAI Hostel Patiala, dated 27-01-2005.
- Three Hammer throwers from India camp, dated- 05-02-2005.
- Six Hammer throwers from State Hostel Allahabad, dated-27-12-2004.
- One Hammer thrower from State Hostel Lucknow, dated- 30-12-2004.
- One Hammer thrower from Indo-Pak Punjab competition, dated -18-02-2005.

The selected subjects belonged to the 15 states of India. Namely -U.P, Punjab, Haryana, Delhi, Bihar, Chhatishgarh, Jharkhand, Karnataka, Kerala, M.P, Maharashtra Uttaranchal, J&K, West Bengal, Andhra Pradesh, Tamilnadu.

CRITERIAN MEASURE

The criterion measures for this study were-

Weight	-	Kilogram
Anthropometrical parameters	-	Centimeter and mm.
Proportionality (indices)	-	Ratios
Somatotype	-	Grading
Body Composition	-	% (percents)

RELIABILITY OF DATA

Reliability of data was ensured by establishing the reliability of anthropometrical Instruments and tester's competency.

INSTRUMENTS RELIABILITY

Anthropometric kit was used for obtaining anthropometric measurements. The instruments were of standard quality. The manufacturer had ensured their accuracy. International society for the advancements of kinanthropometry (ISAK) approved techniques were used for obtaining Anthropometrical data. The reliability was checked by test-retest method and average co-efficient was found to be 0.96.

The following instruments were used for collecting the data

1- Weighing machine

2- Steel measuring tape

3-Stadiometer

4-Vernier caliper

5-Skinfold caliper

6-Sliding caliper

7-Chest caliper

8-Sitting height table

TESTER COMPETENCY

The researcher was well versed in anthropometrical measuring technique he had number of practice sessions under the supervision of Dr.B.B.Singh, Reader department of Physical health & sports education A.M.U.Aligarh.

COLLECTION OF DATA

The data in the from of criterion measure of study described above were collected through the following methods-

1. BODY MASS: - The subjects were examined in clothing of known weight in Kg in order to record nude weight with the help of weighing machine. The position of the subject was anatomical position, the palm face outward eye looking ahead neck and back was straight.

2. STATURE: - Stature in cm. was taken as the maximum distance from the point vertex on the head to the ground. Subject was made to stand erect with heels together and arms hanging naturally by the side and head in the frank fort horizontal plane along a wall on which a measuring tape was fixed. The subject is instructed to "look straight ahead" and "take a deep breath." And the recorder had noted the height up to nearest mm. with the help of measuring tape.

3.SITTING STATURE-: The subject was made to sit on the stool with his legs hanging down freely. The subject was asked to stretch his back as far as possible and to hold his head upright so that Frankfort planes becomes horizontal. Gentle upward pressure was applied to the mastoid processes. The muscles of the thigh and buttock were contracted in order to stretch him full.

The horizontal bar of the anthropometric rod was brought down so that it touched the highest point on the head. The distance between anthropomenter rod and the highest point of the stool was measured.

4. CHEST BREADTH: - The subject stood erect and abducted the arms so as the tape can be placed around the chest. Arms of the subjects were lowered after placing the tape. The measurement was taken through the nipple line at the mid-tidal volume.

5. UPPER ARM LENGTH: -_The subject was made to sit erect with arms hanging down normally with the palm of right hand direction towards thigh. Inferior border of the Acromion process to radiale were marked. The distance between these two points was measured with the help of measuring tape and the value was recorded.

6. LOWER ARM LENGTH: -The subject was made to stand with arms hanging down normally. Radiale and dactylic were marked on the right hand. The distance between two points was recorded with the help of measuring tape.

7. **TOTAL ARM LENGTH:** -The subject was made to stand with arms hanging down normally. Acromion and Dactylion were marked on the right hand. The distance between two points was measured with the help of measuring tape.
8. **UPPER LEG LENGTH**-The subject was made to stand erect with weight equally distributed on both legs. Trochanterion and Tibiale lateral of the right leg was marked. The distances between these two points was measured with the help of measuring tape.
9. **LOWER LEG LENGTH** -: The subject was made to stand erect with body weight equally distributed on the legs. The distance was measured between Tibiale medial to Sphyrion Tibiale with the help of measuring tape.

10. TOTAL LEG LENGTH-: The subject was made to stand erect with body weight equally distributed on the legs. The distance between trochanterion to pternion or grand was measured with the help of measuring tape.

11. FOOT LENGTH-: The subject was standing at plane surface the straight distance between acropodion and pternion, was recorded with the help of measuring tape.

12. SHOULDER BREADTH-: The subject stood with arms by the sides and weight evenly distributed on both legs. The measuring distance between left acromion to right acromion process was recorded from behind the neck..

13.BICEPS MUSCLE GIRTH -: The subject was made to raise his right arm to horizontal position in the sagittal plan with the fully supinated forearms flexed at the elbow to an angle of 45°. The subject was asked to tense his biceps, the measurement was taken with the help of measuring tape wrapped at right angle to the long axis of the upper arm where the maximum girth was possible.

14. CALF MUSCLE GIRTH -: The subject was made to stand erect with body weight equally supported on both legs. The measuring tape was wrapped around the right lower leg and measurement was taken at right angle to the axis of lower leg, where it was maximum.

15. THIGH MUSCLE GIRTH -: The Subject stood erect with arms by sides. The tape was positioned horizontally just below the gluteal furrow about 2/3 of the distance from the mid-knee to the crotch. The measurement was taken with help of measuring tape.

16. HIPS BREADTH; The subject was made to stand erect with sliding caliper applied from behind the subject so that branches of sliding caliper were at the most lateral points on the superior border of the iliac crests.

23

Figure: 2 -Anatomic Locations of the Sites for Girth Measurements

(According to McArdle et.al. 1991)

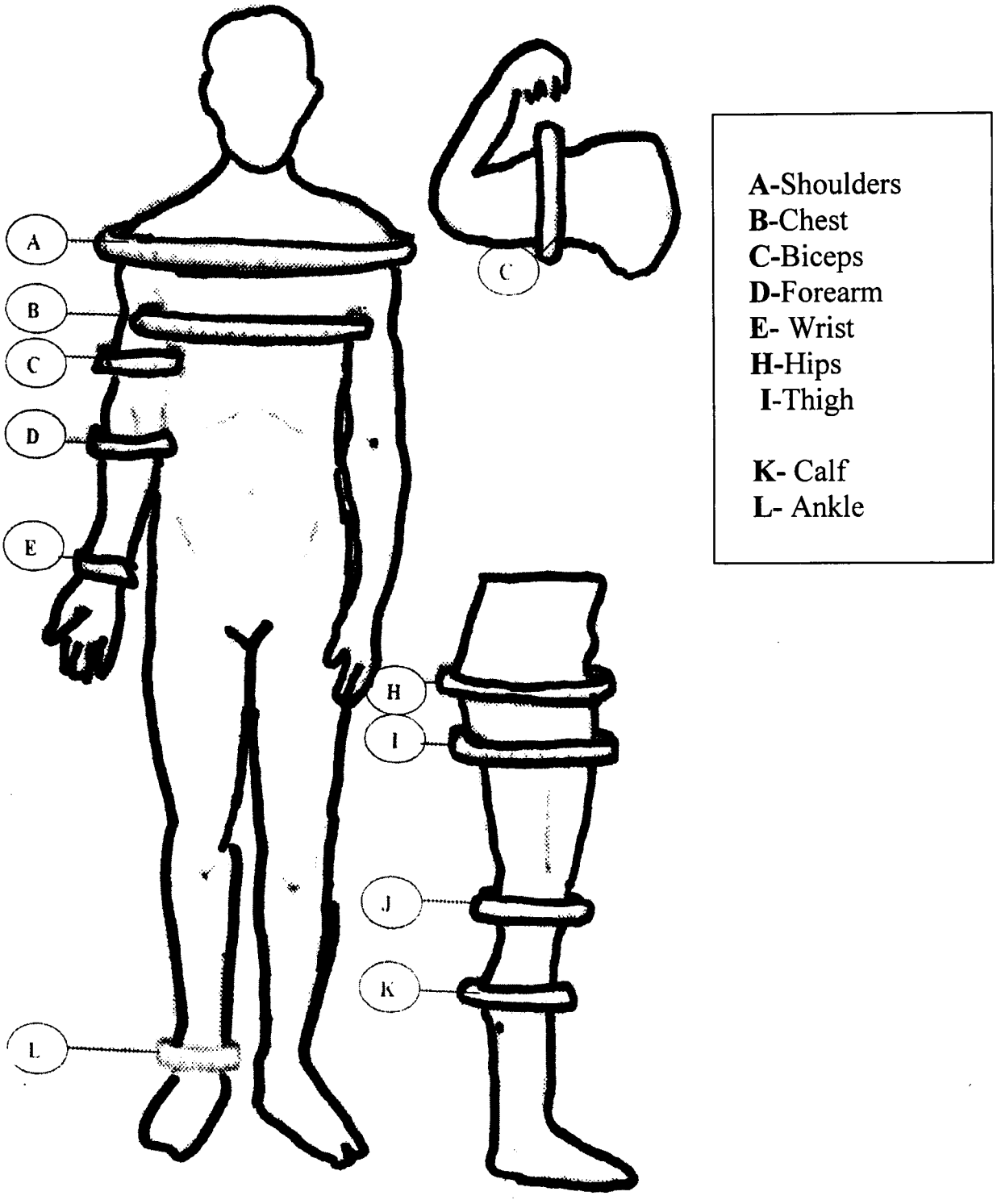


Figure: 3- Landmarks for Skinfold Measurement According to Anthropometric Standardization Manual (Lehman et al. 1988)

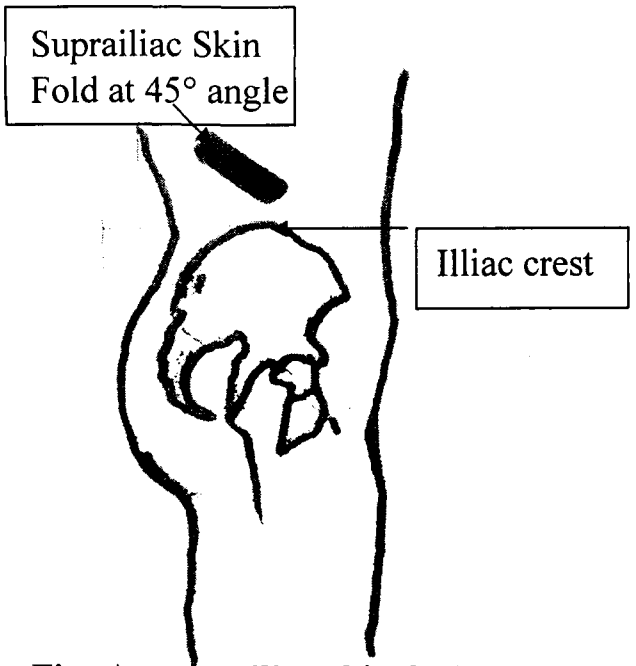


Fig: A superailiac skin fold Skinfold

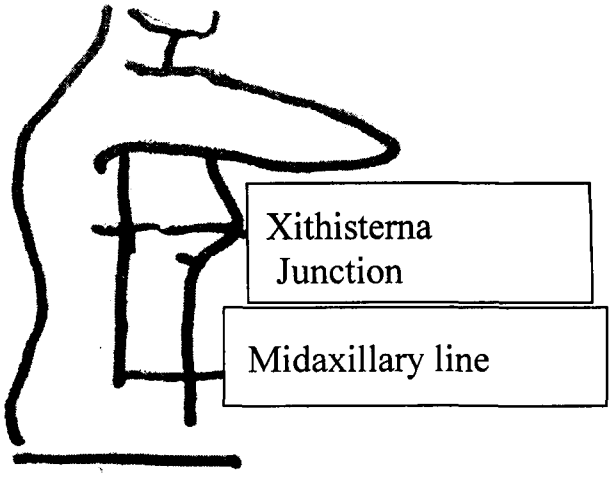


Fig: B Midaxillary

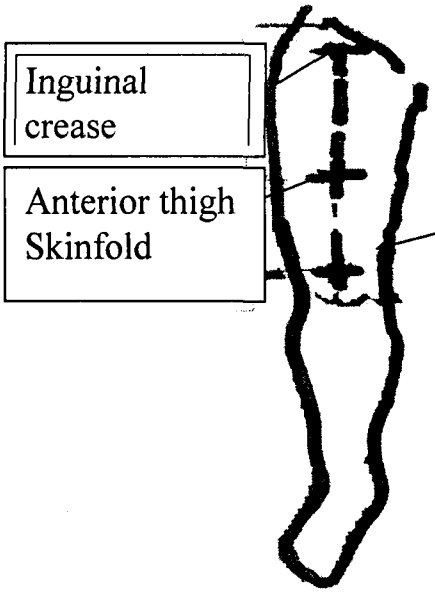


Fig: C Thigh Skinfold

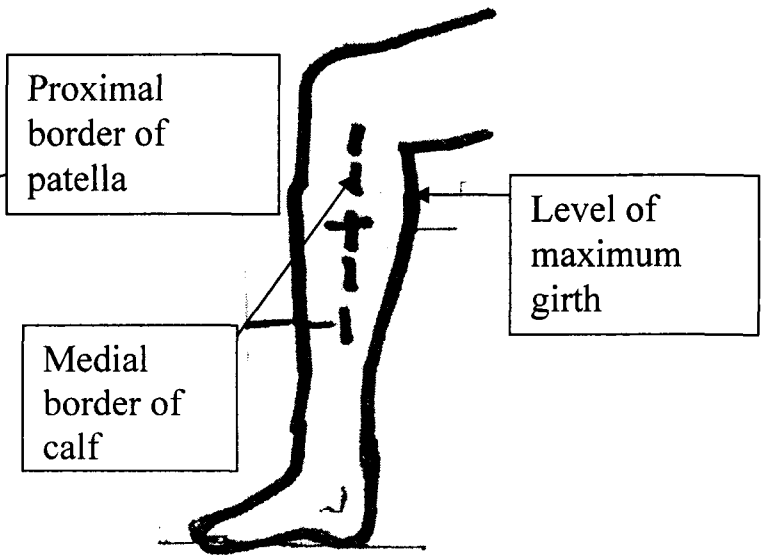
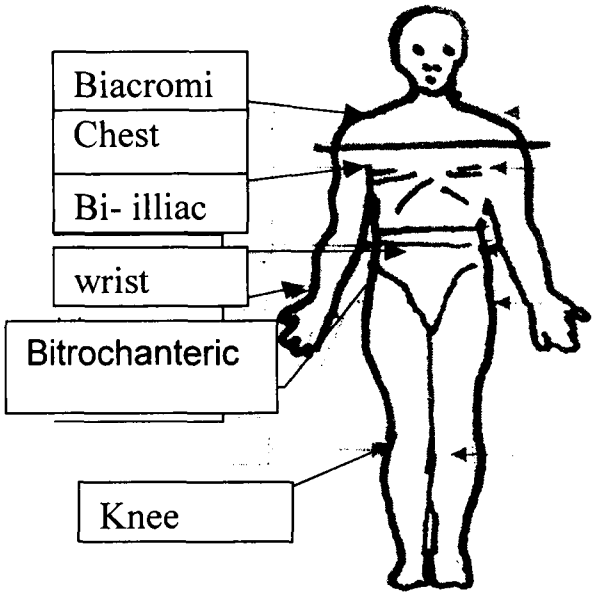
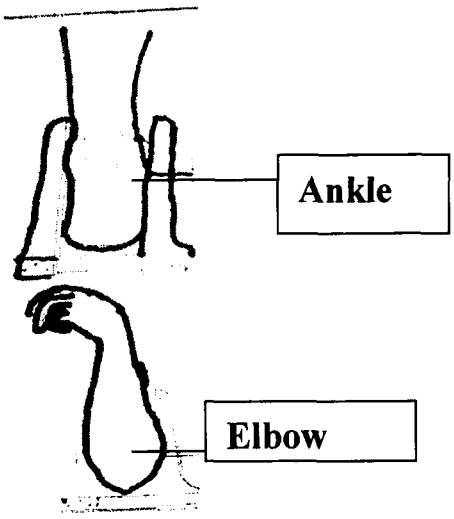


Fig:D Medial calf skin fold

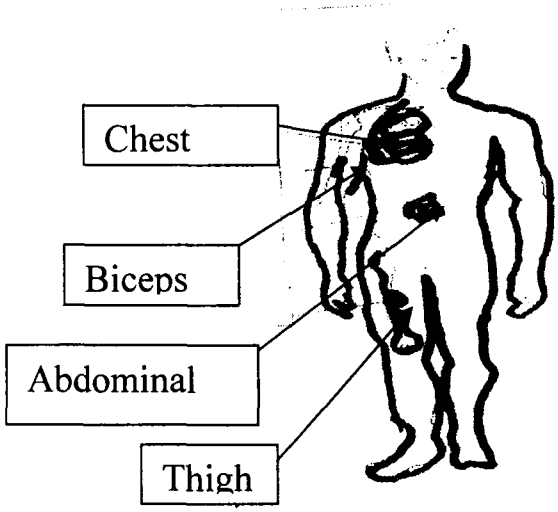
Figure: 4 - Anatomic Locations for the Measurement of Skeletal Diameters and Skin Fold Thickness



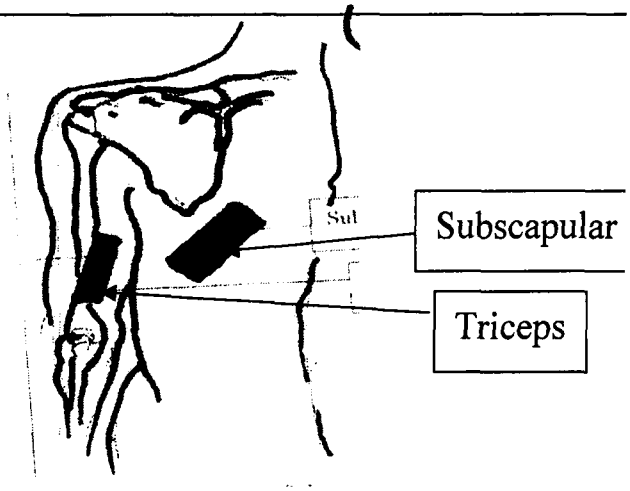
Skeletal Diameters. Diameter.



Ankle and Elbow



Chest, biceps, Abdominal &thigh skin folds



Triceps and Sub scapular skin folds

17. HUMERUS BIEPICONDYLER DIAMETER: - The subject's right arm was raised forward to the horizontal and the forearm flexed to right angle at elbow. The distance between medial and lateral epicondylar of the humerus was measured with the help of Vernier caliper and the value was recorded.

18. FEMUR BIEPICONDYLER DIAMETER: - The subject was made to sit and the right leg was flexed at the knee to from a right angle with thigh. The distance between medial and lateral epicondylar of the femur was measured with the help of vernier caliper and the value was recorded.

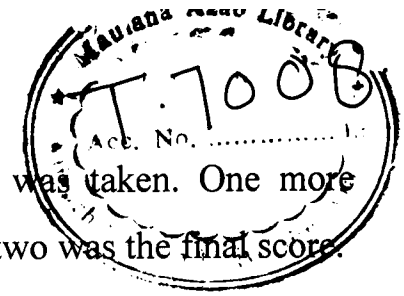
19. FOREARM GIRTH: - Subject stood erect with the arms extended in front of the body and parallel to the floor with the palm supinated. Reading was recorded at the level of maximum circumference with the help of measuring tape.

20. CHEST DEPTH: The subject sit erect on a stool or table and the measurement taken from his anteriorl to posteriorl level of mesosternal point (at the level of 5th to 6th ribs) with the help of chest depth caliper/chest caliper.

21. WRIST BREADTH: The subject sit on stool extends hand towards the anthropometrist with palm facing downwards. He measures the breadth between the most medial and lateral points of the distal epiphyses of radius and ulna, with the help of sliding caliper.

22. ANKLE BREADTH: The subject was seated with foot gently touching the ground. Distance was measured between the sphyrion tibiale to sphyrion fibular with help of the sliding caliper.

23.TRICEPS SKIN FOLD: The mid acromiale-radiale line on the posterior surface of the right arm was marked and the skin fold about one centimeter above marked level was picked up and jaws of the calipers were applied to the



fold and after waiting for 2-3 seconds the reading was taken. One more reading was taken in the same way and average of the two was the final score.

24. SUB SCAPULAR SKIN FOLD: A point below the right scapula was marked. The skin fold about one centimeter below marked level was picked up and jaws of the caliper were applied to the fold and after waiting for 2 - 3 seconds the reading was taken. One more reading was taken by the same procedure and average of the two was the final score.

25. SUPRAILIAC SKIN FOLD: A point above the anterior superior iliac spine on the line to the anterior auxiliary's boarder of right side was marked. The skin fold about 2 to 5 centimeter above marked level was picked up, the caliper was applied to the fold and after waiting for 2 - 3 seconds the reading was taken. One more reading was taken by the same procedure and average of the two was considered.

26. THIGH SKIN FOLD: The skin fold measure was taken on the anterior surface mid-way between the mid-inguinal point and the superior border of patella. The knee should be flexed at 90°.

27. CALF SKIN FOLD: The subject was made to sit on a chair with knees bent at right angles. Medial side of the right calf, slightly above the level of the maximum girth was marked. The skin fold above the marked level was picked up and jaws of the caliper were applied to the fold. After waiting for 2 to 3 seconds the reading was taken. One more reading was taken by the same procedure and average of the two was considered.

28. PERFORMANCE: The subject best performance or distance throwing during the competitions or sports trials.

30. TRAINING AGE: It was total time spent on training till 31 Dec-2005.

31. TOTAL AGE: The subject's total age was calculated from birth to 31 December 2005.

SOMATOTYPE

The following heath and Carter (1984) method was applied to determine Somatotype of subjects;

Endomorphy: -

$-0.7182 + 0.1451 \times {}^{*}\sum SF - 0.00068 \times {}^{*}\sum SF^2 + 0.0000014 \times {}^{*}\sum SF^3$

[Where SF = sum of triceps, sub scapular and supraillic skin fold multiplied by 170.18/height in centimeter].

Mesomorphy

0.858 × humerus breadth + 0.601 × Femur breadth + 0.188 × *Corrected arm girth + 0.161 × *Corrected calf girth – height × 0.131 + 4.5

(* Subtract the triceps skin fold and calfskin fold from the arm girth and calf girth, respectively).

Ectomorphy: - The ectomorphy was determined by comparing the calculated height, weight ratio (HWR) of the subject with the underline values given below.

$$HWR = \frac{\text{Height in cm.}}{\sqrt[3]{\text{Weight in kg}}}$$

- If HWR is greater than or equal to 40.75 than ectomorphy
  =0.732 * HWR - 28.58
- If HWR is less than 40.75 and greater than 38.25 then ectomorphy
  = 0.463*HWR-17.68
- If HWR is equal to or less than 38.25 than ectomorphy = 0.1

Proportionality

The following indices were used to determine various body segmental Proportionality.

- Sitting height –stature index = $\frac{\text{Sitting height}}{\sqrt{\text{Stature}}} \times 100$
- Ponderal Index = $\frac{\text{Stature}}{\sqrt[3]{\text{Weight}}}$
- Thigh Length–lower leg length index = $\frac{\text{Thigh Length}}{\text{Lower leg length}} \times 100$
- Upper arm length –lower arm length index = $\frac{\text{Upper arm length}}{\text{Lower arm length}} \times 100$
- Hip Breadth –Stature Index = $\frac{\text{Hip breadth}}{\text{Stature}} \times 100$
- Shoulder Breadth –Stature Index = $\frac{\text{Shoulder breadth}}{\text{Stature}} \times 100$

BODY COMPOSITION:

Body Fat Percentage: It is body fat mass in terms of percentage and was estimated from the equation of Katch and Mc Ardle:

Body fat (%)= 0.43(A)+ 0.58 (B) +1.47

A= Triceps fat fold (mm)

B= Subscapula fat fold (mm)

STATISTICAL PROCEDURE

Reiterating the objective of the study, we have to point out that we intend to investigate the anthropometrical differences among four types of throwers. Further we also intended to find out the relationship between anthropometrical measurement and the performance of the throwers. Thus we had used analysis of variance to found out the significant difference among the four types of throwers. Where the difference was significant, we had used L.S.D. test to analyse, which group mean was greater than other. Product moment correlation technique was used to find out, the relationship existing between the anthropometrical measurement and performance of the thrower groups.

LEVEL OF SIGNIFICANCE

The significance of differences among thrower's anthropometrical measurements was tested at 0.05 level of significance.

Chapter -IV

Analysis Of Data and Discussion Of Finding

ANALYSIS OF DATA AND DISCUSSION OF FINDINGS

Result of analysis obtained through co-efficient of correlation technique for each of the chosen variable are produced below:

SHOT PUT

Table-6

The correlation between Shot putter's **Height** and performance.

Variable	Correlation
Height	0.31
Performance	

The table shows a positive correlation ship (0.31) between the height of the Shot putter and his performance.

Table: 7

The correlation between Shot putter's **Weight** and performance.

Variable	Correlation
Weight	0.72
Performance	

The table shows a positive correlation ship (0.72) between the weight of the Shot putter and his performance.

Table: 8

The correlation between Shot putter's **Sitting Height** and performance.

Variable	Correlation
Sitting height	0.09
Performance	

The table shows a positive correlation ship (0.09) between the Sitting height of the Shot putter and his performance.

Table: 9

The correlation between Shot putter's **Total age & Training age** and performance.

Variable	Correlation
Total & training age	0.38
Performance	

The table shows a positive correlation ship (0.38) between the Total & training age of the Shot putter and his performance.

Table: 10

The correlation between Shot putter's **Chest girth & Depth** and performance.

Variable	Correlation
Chest girth & depth	0.45
Performance	

The table shows a positive correlation ship (0.45) between the Chest girth & depth of the Shot putter and his performance.

Table: 11

The correlation between Shot putter's **Humerus & Femur Biepicondylar** and performance.

Variable	Correlation
Humerus & femur bie-pico	0.75
Performance	

The table shows a positive correlation ship (0.75) between the Humerus & Femur Biepicondylar of the Shot putter and his performance.

Table: 12

The correlation between Shot putter's **Wrist & Ankle breadth** and performance.

Variable	Correlation
Wrist & Ankle Breadth	0.66
Performance	

The table shows a positive correlation ship (0.66) between the Wrist & ankle breadth of the Shot putter and his performance.

Table: - 13.

The correlation between Shot putter's **Hip & Shoulder breadth** and performance.

Variable	Correlation
Hip & shoulder breadth	0.12
Performance	

The table shows a positive correlation ship (0.12) between the Hip & Shoulder breadth of the Shot putter and his performance.

Table: - 14.

The correlation between Shot putter's **Upper arm length** and performance.

Variable	Correlation
Upper arm length	0.57
Performance	

The table shows a positive correlation ship (0.57) between the Upper arm length of the Shot putter and his performance.

Table: 15

The correlation between Shot putter's **Lower arm length** and performance.

Variable	Correlation
Lower arm length	0.26
Performance	

The table shows a positive correlation ship (0.26) between the Lower arm length of the Shot putter and his performance.

Table: - 16.

The correlation between Shot Putter's **Total arm length** and performance

Variable	Correlation
Total arm length	0.76
Performance	

The table shows a positive correlation ship (0.76) between the Total arm length of the Shot putter and his performance.

Table: 17

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The correlation between Shot putter's **Upper leg length** and performance.

Variable	Correlation
Upper leg length	0.49
Performance	

The table shows a positive correlation ship (0.49) between the Upper leg length of the Shot putter and his performance.

Table: - 18.

The correlation between Shot putter's **Lower leg length** and performance.

Variable	Correlation
Lower leg length	0.37
Performance	

The table shows a positive correlation ship (0.37) between the Lower leg length of the Shot putter and his performance.

Table: 19

The Correlation between Shot putter's **Total leg length** and performance.

Variable	Correlation
Total leg length	0.08
Performance	

The table shows a positive correlation ship (0.08) between the Total leg length of the Shot putter and his performance.

Table: 20

The correlation between Shot putter's **Muscles girth** and performance.

Variable	Correlation
Muscles girth	0.87
Performance	

The table shows a positive correlation ship (0.87) between the Muscles girth of the Shot putter and his performance.

Table: 21

The correlation between Shot putter's **Skin folds** and performance.

Variable	Correlation
Skin fold	0.55
Performance	

The table shows a positive correlation ship (0.55) between the Skin fold of the Shot putter and his performance.

Table: 22

The Correlation between Shot putter's **Foot length** and performance

Variable	Correlation
Skin fold	-0.018
Performance	

The table shows a negative correlation ship (-0.018) between the foot length of the Shot putter and his performance.

Table: 23

The correlation between Shot putter's **Endomorphy** and performance.

Variable	Correlation
Endomorphy	0.43
Performance	

The table shows a positive correlation ship (0.43) between the Endomorphy of the Shot putter and his performance.

Table: 24

The correlation between Shot putter's **Mesomorphy** and performance

Variable	Correlation
Mesomorphy	-0.22
Performance	

The table shows a negative correlation ship (-0.22) between the Mesomorphy of the Shot putter and his performance.

Table: 25

The correlation between Shot putter's **Ectomorphy** and performance.

Variable	Correlation
Ectomorphy	-0.48
Performance	

The table shows a negative correlation ship (-0.48) between the Ectomorphy of the Shot putter and his performance.

Table: 26

The correlation between Shot putter's **Sitting height-Stature index** and performance.

Variable	Correlation
Sitting Height-Stature Index	0.19
Performance	

The table shows a positive correlation ship (0.19) between the Sitting height-Stature index of the shot putter and his performance.

Table: 27

The correlation between Shot putter's **Ponderal index** and performance.

Variable	Correlation
Ponderal index	-0.48
Performance	

The table shows a negative correlation ship (-0.48) between the Ponderal index of the Shot putter and his performance.

Table: 28

The correlation between Shot putter's **Thigh length- Lower leg length index** and performance

Variable	Correlation
Thigh length-lower leg length index.	0.04
Performance	

The table shows a positive correlation ship (0.04) between the Thigh length-lower leg length index of the Shot putter and his performance.

Table: 29

The correlation between Shot putter's **Upper arm length- Lower arm length index** and performance.

Variable	Correlation
Upper Arm Length-Lower Arm Length	0.38
Performance	

The table shows a positive correlation ship (0.38) between the Upper arm length- lower arm length index of the Shot putter and his performance.

Table: 30

The correlation between Shot putter's **Hip breadth -Stature index** and performance

Variable	Correlation
Hip breadth-stature index.	-0.06
Performance	

The table shows a negative correlation ship (-0.06) between the Hip breadth-Stature index of the Shot putter and his performance.

Table: 31

The correlation between Shot putter's **Shoulder breadth -Stature index** and performance.

Variable	Correlation
Shoulder breadth-stature index.	0.04
Performance	

The table shows a positive correlation ship (0.04) between the Shoulder breadth -Stature index of the Shot putter and his performance.

Table: 32

The correlation between Shot putter's **Body composition** and performance.

Variable	Correlation
Body composition	0.54
Performance	

The table shows a positive correlation ship (0.54) between the Body composition of the Shot putter and his performance.

DISCUS THROW

Table: 33

The correlation between Discus thrower's **Total age & Training age** and performance

Variable	Correlation
Total Age & Training Age	0.19
Performance	

The table shows a positive correlation ship (0.19) between the Total age & training age of the Discus thrower and his performance.

Table: 34

The correlation between Discus thrower's **Weight** and performance.

Variable	Correlation
Weight	0.51
Performance	

The table shows a positive correlation ship (0.51) between the Weight of the Discus thrower and his performance.

Table: 35

The correlation between Discus thrower's **Height** and performance.

Variable	Correlation
Height	-0.13
Performance	

The table shows a negative correlation ship (-0.13) between the Height of the Discus thrower and his performance.

Table: 36

The correlation between Discus thrower's **Sitting height** and performance.

Variable	Correlation
Sitting height	0.45
Performance	

The table shows a positive correlation ship (0.45) between the Sitting height of the Discus thrower and his performance.

Table: 37

The correlation between Discus thrower's **Chest girth & depth** and performance.

Variable	Correlation
Chest girth & depth	-0.33
Performance	

The table shows a negative correlation ship (-0.33) between the Chest girth & depth of the Discus thrower and his performance.

Table: 38

The correlation between Discus thrower's **Humerus & Femur Biepicondylar** and performance.

Variable	Correlation
Humerus & femur Biepicondylar	0.74
Performance	

The table shows a positive correlation ship (0.74) between the Humerus & femur Biepicondylar of the Discus thrower and his performance.

Table: 39

The correlation between Discus thrower's **Wrist & Ankle breadth** and performance.

Variable	Correlation
Wrist & Ankle Breadth	-0.29
Performance	

The table shows a negative correlation ship (-0.29) between the Wrist & ankle breadth of the Discus thrower and his performance.

Table: 40

The correlation between Discus thrower's **Hip & Shoulder breadth** and performance.

Variable	Correlation
Hip & Shoulder Breadth	-0.14
Performance	

The table shows a negative correlation ship (-0.14) between the Hip & shoulder breadth of the Discus thrower and his performance.

Table: 41

The correlation between Discus thrower's **Upper arm length** and performance.

Variable	Correlation
Upper Arm Length	-0.22
Performance	

The table shows a negative correlation ship (-0.22) between the Upper arm length of the Discus thrower and his performance.

Table: 42

The correlation between Discus thrower's **Lower arm length** and performance.

Variable	Correlation
Lower arm length	0.04
Performance	

The table shows a positive correlation ship (0.04) between the Lower arm length of the Discus thrower and his performance.

Table: 43

The correlation between Discus thrower's **Total arm length** and performance.

Variable	Correlation
Total arm length	0.1
Performance	

The table shows a positive correlation ship (0.1) between the Total arm length of the Discus thrower and his performance.

Table: 44

The correlation between Discus thrower's **Upper leg length** and performance.

Variable	Correlation
Upper leg length	-0.38
Performance	

The table shows a negative correlation ship (-0.38) between the Upper leg length of the Discus thrower and his performance.

Table: 45

The correlation between Discus thrower's **Lower leg length** and performance

Variable	Correlation
Lower leg length	-0.32
Performance	

The table shows a negative correlation ship (-0.32) between the Lower leg length of the Discus thrower and his performance.

Table: 46

The correlation between Discus thrower's **Total leg length** and performance.

Variable	Correlation
Total leg length	0.05
Performance	

The table shows a positive correlation ship (0.05) between the Total leg length of the Discus thrower and his performance.

Table: 47

The Correlation between Discus thrower's **Muscles girth** and performance.

Variable	Correlation
Muscles girth	-0.33
Performance	

The table shows a negative correlation ship (-0.33) between the Muscles girth of the Discus thrower and his performance.

Table: 48

The correlation between Discus thrower's **Skin fold** and performance.

Variable	Correlation
Skin fold	0.08
Performance	

The table shows a positive correlation ship (0.08) between the Skin fold of the Discus thrower and his performance.

Table-49

The correlation between Discus thrower's **Foot length** and performance.

Variable	Correlation
Skin fold	-0.002
Performance	

The table shows a negative correlation ship (-0.002) between the foot length of the Discus thrower and his performance.

Table: 50

The correlation between Discus thrower's **Endomorphy** and performance.

Variable	Correlation
Endomorphy	0.11
Performance	

The table shows a positive correlation ship (0.11) between the Endomorphy of the Discus thrower and his performance.

Table: 51

The correlation between Discus thrower's **Mesomorphy** and performance.

Variable	Correlation
Mesomorphy	-0.33
Performance	

The table shows a negative correlation ship (-0.33) between the Mesomorphy of the Discus thrower and his performance.

Table: 52

The correlation between Discus thrower's **Ectomorphy** and performance.

Variable	Correlation
Ectomorphy	0.37
Performance	

The table shows a positive correlation ship (0.37) between the Ectomorphy of the Discus thrower and his performance.

Table: 53

The correlation between Discus thrower's **Sitting height-Stature index** and performance.

Variable	Correlation
Sitting height-stature index	0.22
Performance	

The table shows a positive correlation ship (0.22) between the Sitting height-Stature index of the Discus thrower and his performance.

Table: 54

The correlation between Discus thrower's **Ponderal index** and performance.

Variable	Correlation
Ponderal Index	0.37
Performance	

The table shows a positive correlation ship (0.37) between the Ponderal index of the Discus thrower and his performance.

Table: 55

The correlation between Discus thrower's **Thigh length-Lower leg length index** and performance.

Variable	Correlation
Thigh length–lower leg length index.	0.02
Performance	

The table shows a positive correlation ship (0.02) between the Thigh length-lower leg length index of the Discus thrower and his performance.

Table: 56

The correlation between Discus thrower's **Upper arm length-Lower arm length** and performance.

Variable	Correlation
Upper Arm Length-Lower Arm Length	
Performance	-0.31

The table shows a negative correlation ship (-0.31) between the Upper arm length-lower arm length of the Discus thrower and his performance.

Table: 57

The correlation between Discus thrower's **Hip breadth-Stature index** and performance.

Variable	Correlation
Hip breadth-stature index.	-0.46
Performance	

The table shows a negative correlation ship (-0.46) between the Hip breadth-Stature index of the Discus thrower and his performance.

Table: 58

The correlation between Discus thrower's **Shoulder breadth -Stature index** and performance.

Variable	Correlation
Shoulder breadth-stature index.	-0.34
Performance	

The table shows a negative correlation ship (-0.34) between the Shoulder breadth-Stature index of the Discus thrower and his performance.

Table-59

The correlation between Discus thrower's **Body composition / Fat%** and performance.

Variable	Correlation
Body composition	0.09
Performance	

The table shows a positive correlation ship (0.09) between the Body composition of the Discus thrower and his performance.

JAVELIN

Table: 60

The correlation between Javelin thrower's **Total age & training age** and performance.

Variable	Correlation
Total Age & Training Age	0.07
Performance	–

The table shows a positive correlation ship (0.07) between the Total age & training age of the Javelin thrower and his performance.

Table: 61

The correlation between Javelin thrower's **Weight** and performance.

Variable	Correlation
Body weight	-0.33
Performance	

The table shows a negative correlation ship (-0.33) between the Body weight of the Javelin thrower and his performance.

Table: 62

The correlation between Javelin thrower's **Height** and performance.

Variable	Correlation
Body height	0.15
Performance	

The table shows a positive correlation ship (0.15) between the Body height of the Javelin thrower and his performance.

Table: 63

The correlation between Javelin thrower's **Sitting height** and performance.

Variable	Correlation
Sitting height	-0.08
Performance	

The table shows a negative correlation ship (-0.08) between the Sitting height of the Javelin thrower and his performance.

Table: 64

The correlation between Javelin thrower's **Humerus & Femur Biepicondylar** and performance.

Variable	Correlation
Humerus & Femur Biepicondylar	-0.19
Performance	

The table shows a negative correlation ship (-0.19) between the Humerus & femurs Biepicondylar of the Javelin thrower and his performance.

Table: 65

The correlation between Javelin thrower's **Chest girth & Depth** and performance.

Variable	Correlation
Chest Girth & Depth	0.40
Performance	

The table shows a positive correlation ship (0.40) between the Chest girth depth of the Javelin thrower and his performance.

Table: 66

The correlation between Javelin thrower's **Wrist & Ankle breadth** and performance.

Variable	Correlation
Wrist & ankle breadth	- 0.15
Performance	

The table shows a negative correlation ship (-0.15) between the Wrist & ankle breadth of the Javelin thrower and his performance.

Table: 67

The correlation between Javelin thrower's **Hip & Shoulder breadth** and performance

Variable	Correlation
Hip & shoulder breadth	0.05
Performance	

The table shows a positive correlation ship (0.05) between the Hip & Shoulder breadth of the Javelin thrower and his performance.

Table-68

The correlation between Javelin thrower's **Upper arm length** and performance.

Variable	Correlation
Upper arm length	- 0.29
Performance	

The table shows a negative correlation ship (-0.29) between the Upper arm length of the Javelin thrower and his performance.

Table: 69

The correlation between Javelin thrower's **Lower arm length** and performance.

Variable	Correlation
Lower arm length	-.39
Performance	

The table shows a negative correlation ship (-0.39) between the Lower arm length of the Javelin thrower and his performance.

Table: 70

The correlation between Javelin thrower's **Total arm length** and performance.

Variable	Correlation
Total Arm Length	
Performance	- 0.03

The table shows a negative correlation ship (-0.03) between the Total arm length of the Javelin thrower and his performance.

Table: 71

The correlation between Javelin thrower's **Upper leg length** and performance.

Variable	Correlation
Upper Leg Length	
Performance	0.23

The table shows a positive correlation ship (0.23) between the Upper leg length of the Javelin thrower and his performance.

Table: 72

The correlation between Javelin thrower's **Lower leg length** and performance.

Variable	Correlation
Lower leg length	0.46
Performance	

The table shows a positive correlation ship (0.46) between the Lower leg length of the Javelin thrower and his performance.

Table: 73

The correlation between javelin thrower's **Total leg length** and performance.

Variable	Correlation
Total leg length	0.26
Performance	

The table shows a positive correlation ship (0.26) between the Total leg length of the Javelin thrower and his performance.

Table: 74

The correlation between Javelin thrower's **Muscles girth** and performance.

Variable	Correlation
Muscles girth	0.32
Performance	

The table shows a positive correlation ship (0.32) between the Muscles girth of the Javelin thrower and his performance.

Table: 75

The correlation between Javelin Thrower's **Skin fold** and performance.

Variable	Correlation
Skin fold	0.06
Performance	

The table shows a positive correlation ship (0.06) between the Skin fold of the Javelin thrower and his performance.

Table-76

The correlation between Javelin thrower's **Foot length** and performance.

Variable	Correlation
Skin fold	-0.36
Performance	

The table shows a negative correlation ship (-0.36) between the Foot length of the Javelin thrower's and his performance.

Table: 77

The correlation between Javelin thrower's **Endomorphy** and performance.

Variable	Correlation
Endomorphy	0.06
Performance	

The table shows a positive correlation ship (0.06) between the Endomorphy of the Javelin thrower and his performance.

Table: 78

The correlation between Javelin thrower's **Mesomorphy** and performance.

Variable	Correlation
Mesomorphy	
Performance	0.12

The table shows a positive correlation ship (0.12) between the Mesomorphy of the Javelin thrower and his performance.

Table: 79

The correlation between Javelin thrower's **Ectomorphy** and performance.

Variable	Correlation
Ectomorphy	
Performance	0.25

The table shows a positive correlation ship (0.25) between the Ectomorphy of the Javelin thrower and his performance.

Table: 80

The correlation between Javelin thrower's **Sitting height- Stature index** and performance.

Variable	Correlation
Sitting Height-Stature Index	-0.18
Performance	

The table shows a negative correlation ship (-0.18) between the Sitting height-Stature index of the Javelin thrower and his performance.

Table: 81

The correlation between Javelin thrower's **Ponderal index** and performance.

Variable	Correlation
Ponderal index	0.23
Performance	

The table shows a positive correlation ship (0.23) between the Ponderal index of the Javelin thrower and his performance.

Table: 82

The correlation between Javelin thrower's **Thigh length-Lower leg length index** and performance.

Variable	Correlation
Thigh length –lower leg length index.	-0.18
Performance	

The table shows a negative correlation ship (-0.18) between the Thigh length-Lower leg length index of the Javelin thrower and his performance.

Table: 83

The correlation between Javelin thrower's **Upper arm length - Lower arm length index** and performance.

Variable	Correlation
Upper arm length-lower arm length	0.23
Performance	

The table shows a positive correlation ship (0.23) between the Upper arm length-Lower arm length of the Javelin thrower and his performance.

Table: 84

The correlation between Javelin thrower's **Hip breadth-Stature index** and performance.

Variable	Correlation
Hip breadth-stature index.	0.14
Performance	

The table shows a positive correlation ship (0.14) between the Hip breadth-Stature index of the Javelin thrower and his performance.

Table: 85

The correlation between Javelin thrower's **Shoulder breadth-Stature index** and performance.

Variable	Correlation
Shoulder breadth-stature index.	-0.34
Performance	

The table shows a negative correlation ship (-0.34) between the Shoulder breadth -Stature index of the Javelin thrower and his performance.

Table-86

The correlation between Javelin thrower's **Body composition/ Fat%** and performance.

Variable	Correlation
Body composition	
Performance	0.16

The table shows a positive correlation ship (0.16) between the Body composition of the Javelin thrower and his performance.

HAMMER

Table: 87

The correlation between Hammer thrower's **Total age & Training age** and performance.

Variable	Correlation
Total age & training age	
Performance	0.55

The table shows a positive correlation ship (0.55) between the Total age & training age of Hammer thrower and his performance.

Table: 88

The correlation between Hammer thrower's **Weight** and performance.

Variable	Correlation
Weight	0.23
Performance	

The table shows a positive correlation ship (0.23) between the Weight of Hammer thrower and his performance.

Table: 89

The correlation between Hammer thrower's **Height** and performance.

Variable	Correlation
Height	0.26
Performance	

The table shows a positive correlation ship (0.26) between the Height of Hammer thrower and his performance.

Table: 90

The correlation between Hammer thrower's **Sitting height** and performance.

Variable	Correlation
Sitting Height	0.6
Performance	

The table shows a positive correlation ship (0.6) between the Sitting height of Hammer thrower and his performance.

Table: 91

The correlation between Hammer thrower's **Chest girth & Depth** and performance.

Variable	Correlation
Chest girth &depth	0.19
Performance	

The table shows a positive correlation ship (0.19) between the Chest girth & depth of Hammer thrower and his performance.

Table: 92

The correlation between Hammer thrower's **Humerus & Femur Biepicondylar** and performance.

Variable	Correlation
Humerus & femur biepicondylar	0.28
Performance	

The table shows a positive correlation ship (0.28) between the Humerus & Femur Biepicondylar of Hammer thrower and his performance.

Table: 93

The correlation between Hammer thrower's **Wrist & Ankle breadth** and performance.

Variable	Correlation
Wrist & ankle breadth	0.17
Performance	

The table shows a positive correlation ship (0.17) between the Wrist & Ankle breadth of Hammer thrower and his performance.

Table: 94

The correlation between Hammer thrower's **Hip & Shoulder breadth** and performance.

Variable	Correlation
Hip & shoulder breadth	0.17
Performance	

The table shows a positive correlation ship (0.17) between the Hip & shoulder breadth of Hammer thrower and his performance.

Table: 95

The correlation between Hammer thrower's **Upper arm length** and performance.

Variable	Correlation
Upper arm length	0.23
Performance	

The table shows a positive correlation ship (0.23) between the Upper arm length of Hammer thrower and his performance.

Table: 96

The correlation between Hammer thrower's **Lower arm length** and performance.

Variable	Correlation
Lower arm length	0.06
Performance	

The table shows a positive correlation ship (0.06) between the Lower arm length of Hammer thrower and his performance.

Table: 97

The correlation between Hammer thrower's **Total arm length** and performance.

Variable	Correlation
Total arm length	0.83
Performance	

The table shows a positive correlation ship (0.83) between the Total arm length of Hammer thrower and his performance.

Table: 98

The correlation between Hammer thrower's **Upper leg length** and performance.

Variable	Correlation
Upper leg length	0.12
Performance	

The table shows a positive correlation ship (0.12) between the Upper leg length of Hammer thrower and his performance.

Table: 99

The correlation between Hammer thrower's **Lower leg length** and performance.

Variable	Correlation
Lower leg length	0.02
Performance	

The table shows a positive correlation ship (0.02) between the Lower leg length of Hammer thrower and his performance.

Table: 100

The correlation between Hammer thrower's **Total leg length** and performance.

Variable	Correlation
Total Leg Length	0.31
Performance	

The table shows a positive correlation ship (0.31) between the Total leg length of Hammer thrower and his performance.

Table: 101

The correlation between Hammer thrower's **Muscles girth** and performance.

Variable	Correlation
Muscles girth	0.09
Performance	

The table shows a positive correlation ship (0.09) between the Muscles girth of Hammer thrower and his performance.

Table: 102

The correlation between Hammer thrower's **Skin fold** and performance.

Variable	Correlation
Skin fold	0.22
Performance	

The table shows a positive correlation ship (0.22) between the Skin fold of Hammer thrower and his performance.

Table-103

The correlation between Hammer thrower's **Foot length** and performance.

Variable	Correlation
Skin fold	0.207
Performance	

The table shows a positive correlation ship (0.207) between the Foot length of the Hammer thrower and his performance.

Table: 104

The correlation between Hammer thrower's **Endomorphy** and performance.

Variable	Correlation
Endomorphy	0.15
Performance	

The table shows a positive correlation ship (0.15) between the Endomorphy of the Hammer thrower and his performance.

Table: 105

The correlation between Hammer thrower's **Mesomorphy** and performance.

Variable	Correlation
Mesomorphy	-0.04
Performance	

The table shows a negative correlation ship (-0.04) between the Mesomorphy of the Hammer thrower and his performance.

Table: 106

The correlation between Hammer thrower's **Ectomorphy** and performance.

Variable	Correlation
Ectomorphy	-0.3
Performance	

The table shows a negative correlation ship (-0.3) between the Ectomorphy of the Hammer thrower and his performance.

Table: 107

The correlation between Hammer thrower's **Sitting height-Stature index** and performance.

Variable	Correlation
Sitting height-stature index	0.24
Performance	

The table shows a positive correlation ship (0.24) between the Sitting height-Stature index of the Hammer thrower and his performance.

Table: 108

The correlation between Hammer thrower's **Ponderal index** and performance.

Variable	Correlation
Ponderal Index	-0.3
Performance	

The table shows a negative correlation ship (-0.3) between the Ponderal index of the Hammer thrower and his performance.

Table: 109

The correlation between Hammer thrower's **Thigh length-Lower leg length index** and performance.

Variable	Correlation
Thigh length –lower leg length index.	0.07
Performance	

The table shows a positive correlation ship (0.07) between the Thigh Length-Lower leg length index of the Hammer thrower and his performance.

Table: 110

The correlation between Hammer thrower's **Upper arm length-Lower arm length index** and performance.

Variable	Correlation
Upper Arm Length-Lower Arm Length	0.24
Performance	

The table shows a positive correlation ship (0.24) between the Upper arm Length-Lower arm length of the Hammer thrower and his performance.

Table: 111

The correlation between Hammer thrower's **Hip breadth-Stature index** and performance.

Variable	Correlation
Hip breadth-stature index.	-0.11
Performance	

The table shows a negative correlation ship (-0.11) between the Hip breadth-stature index of the Hammer thrower and his performance.

Table: 112

The correlation between Hammer thrower's **Shoulder breadth -Stature index** performance.

Variable	Correlation
Shoulder breadth-stature index.	0.02
Performance	

The table shows a positive correlation ship (0.02) between the Shoulder breadth -Stature index of the Hammer thrower and his performance.

Table-113

The correlation between Hammer thrower's **Fat%** and performance.

Variable	Correlation
Body composition/fat%.	0.03
Performance	

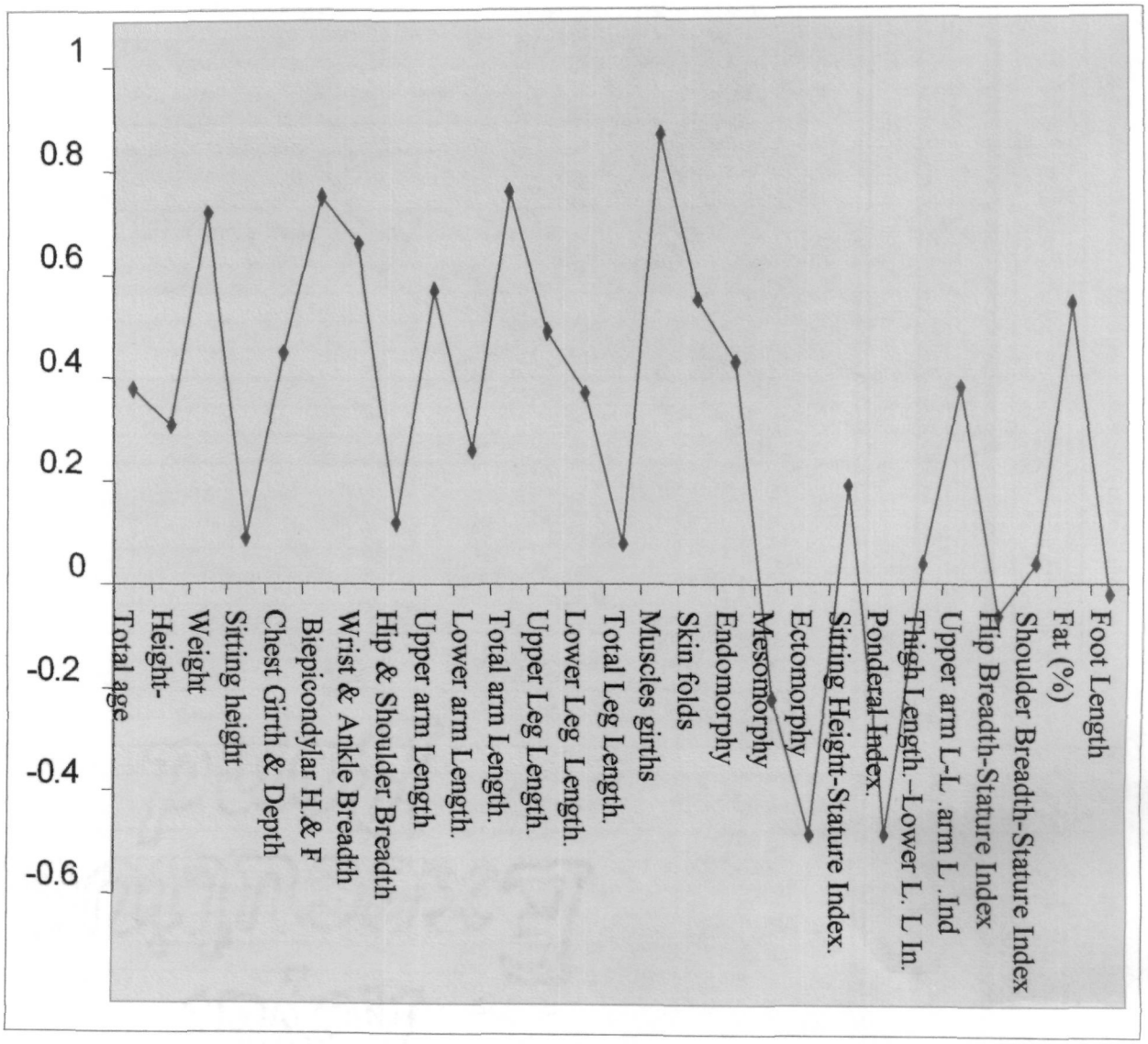
The table shows a positive correlation ship (0.03) between the Body Fat of the Hammer thrower and his performance.

Table –114

Inter Group Comparison of Correlation's

VARIABLES	SP	DT	JT	HT
Total age & total training	0.38	0.19	0.07	0.55
Height-	0.31	-0.13	0.15	0.26
Weight	0.72	0.51	-0.33	0.23
Sitting height	0.09	0.45	-0.08	0.6
Chest girth & depth	0.45	-0.33	0.4	0.19
Humerus & femur-Biepicondylar	0.75	0.74	-0.19	0.28
Wrist & Ankle breadth	0.66	-0.29	- 0.15	0.17
Hip & Shoulder breadth	0.12	-0.14	0.05	0.17
Upper arm length	0.57	-0.22	-0.29	0.23
Lower arm length	0.26	0.04	-0.39	0.06
Total arm length	0.76	0.1	-0.03	0.83
Upper leg length	0.49	-0.38	0.23	0.12
Lower leg length	0.37	-0.32	0.46	0.02
Total leg length	0.08	0.05	0.26	0.31
Muscles girths	0.87	-0.33	0.32	0.09
Skin folds	0.55	0.08	0.06	0.22
Endomorphy	0.43	0.11	0.06	0.15
Mesomorphy	-0.22	-0.33	0.12	-0.04
Ectomorphy	-0.48	0.37	0.25	-0.3
Sitting height-stature Index	0.19	0.22	-0.18	0.24
Ponderal Index	-0.48	0.37	0.23	-0.3
Thigh length –lower leg length index	0.04	0.02	-0.18	0.07
Upper arm length lower arm length index	0.38	-0.3	0.23	0.24
Hip breadth-Stature Index	-0.06	-0.46	0.14	-0.11
Shoulder breadth-Stature Index	0.04	-0.34	-0.34	0.02
Fat Percentage (%)	0.54	0.09	0.16	0.03
Foot Length	-0.018	-0.002	-0.36	0.207

Shot put



Figure– 5. Correlation graph of Shot putters, anthropometrical variables with their performance.

DISCUS THROW

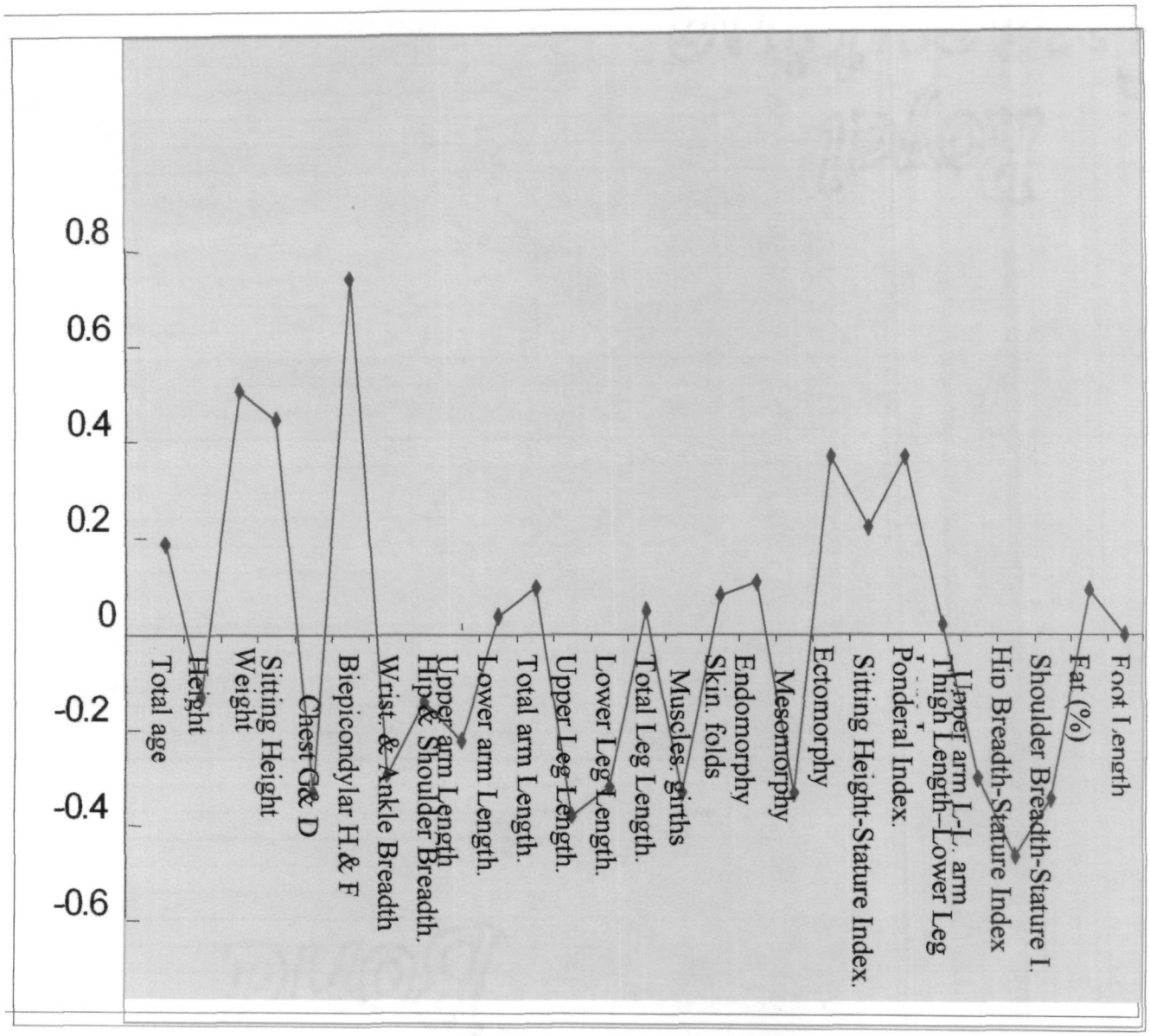


Figure-6. Correlation graph of Discus throwers, anthropometrical variables with their performance.

JAVELIN THROW

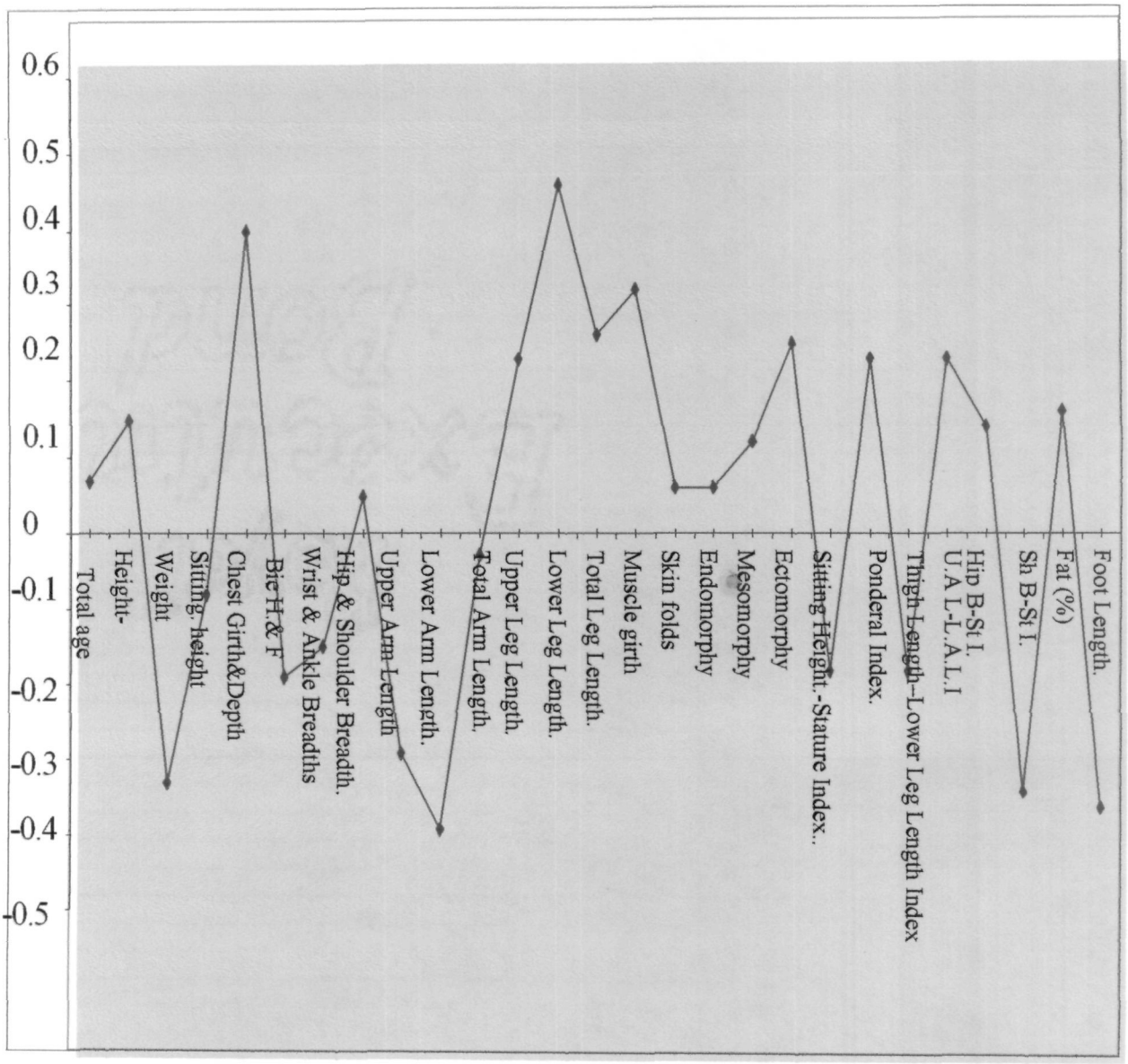


Figure-7. Correlation graph of Javelin thrower, anthropometrical variables with their performance.

HAMMER THROW

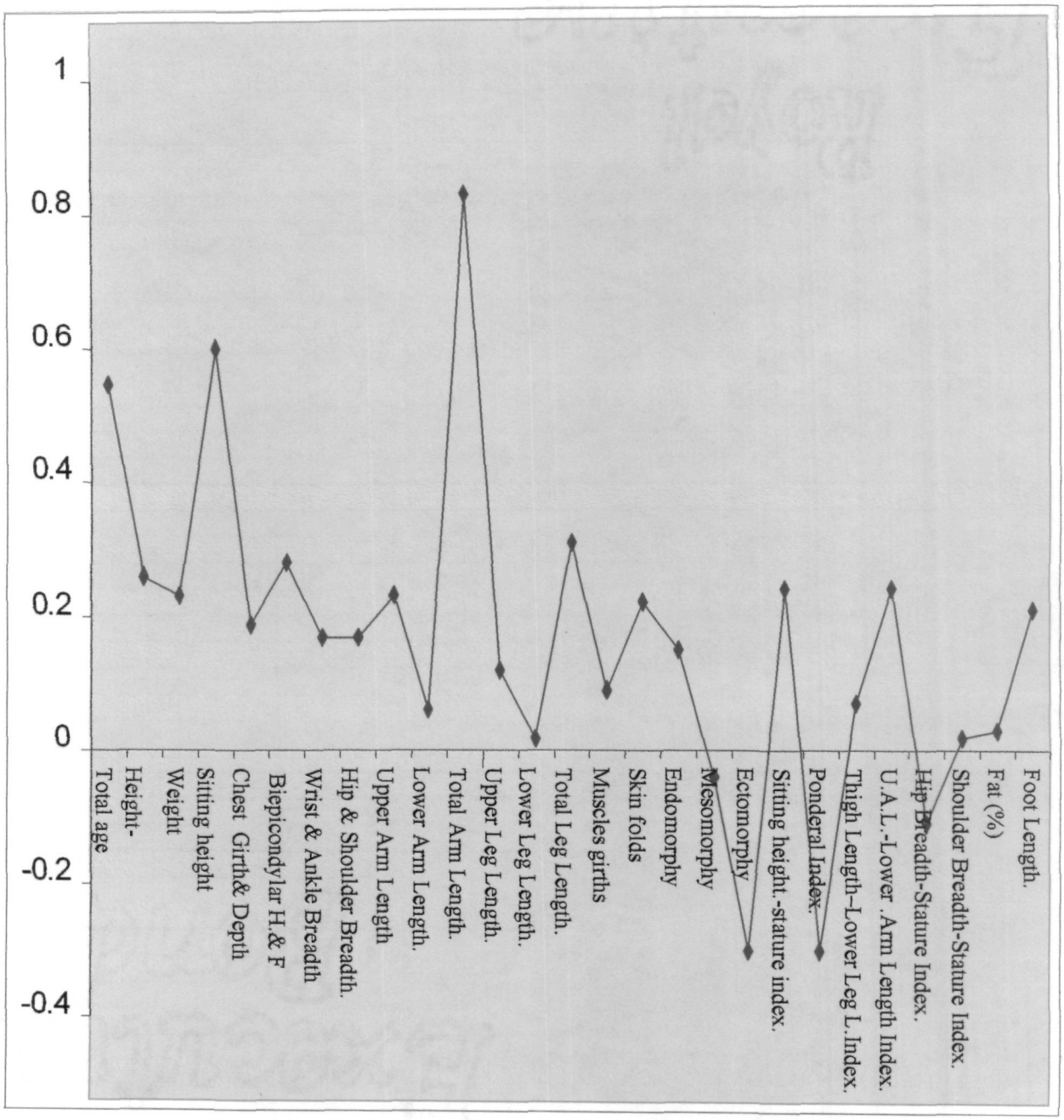


Figure-8. Correlation graph of Hammer throwers, anthropometrical variables with their performance.

Correlation values in table-114 show that, total age and training age of Hammer thrower is having greater positive correlation (.55) with performance, than Shot putter (.38) followed by Discus thrower (.19). Total age & training age of Javelin thrower is least positively correlated (0.07), with performance.

Height of Shot putter is having greater positive correlation (.31) with performance, than Hammer thrower (.26), followed by Javelin thrower (.15). However height of Discus thrower is negatively correlated (-13) with his performance.

Weight of Shot putter is having more positive greater correlation (.72) with performance, than Discus thrower (.51) followed by Hammer thrower (.23). However weight of Javelin thrower is negatively correlated (-.33) with his performance.

Sitting height of Hammer thrower is having greater positive correlation (.60) with performance, than Discus thrower (.45) followed by Shot putter (.09). However Sitting height of Javelin thrower is negatively (-.08) correlated with his performance.

Chest girth & Depth of Shot putter is having greater positive correlation (.45) with performance, than Javelin thrower (.40) followed by Hammer thrower (.19). However Chest girth & Depth of Discus thrower is negatively correlated (-.33) with his performance.

Humerus & Femur Biepicondylar of Shot putter is having greater positive correlation (.75) with performance, than Discus thrower (.74) followed by Hammer thrower (.28). However humerus & femur biepicondylar of Javelin thrower is negatively correlated
(-.19) with his performance.

Wrist & Ankle breadth of Shot putter is having greater positive correlation (.66) with performance, than Hammer thrower (.17). Where as

wrist & ankle breadth of Discus thrower is more negatively correlated (-. 29) with his performance, than Javelin throwers correlation (-. 15) with his performance.

Hip & Shoulder breadth of Hammer thrower is having greater positive correlation (.17) with performance, than Shot putter (.12) followed by Javelin thrower (.05). However Hip & Shoulder breadth of Discus thrower is negatively correlated (-.14) with his performance.

Upper arm length of Shot putter is having greater positive correlation (.57) with performance, than Hammer thrower (.23). However Upper arm length of Javelin thrower is more negatively correlated (-.29) with his performance, than Discus thrower (-.22).

Lower arm length of Shot putter is having greater positive correlation (.26) with performance, than Hammer thrower (.06) followed by Discus thrower (.04). However lower arm length of Javelin thrower is negatively correlated (-.39) with his performance.

Total arm length of Hammer thrower is having greater positive correlation (.83) with performance, than Shot putter (.76) followed by Discus thrower (.10). However Total arm length of Javelin thrower is negatively correlated (-.19) with his performance.

Upper leg length of Shot putter is having greater positive correlation (.49) with performance, than Javelin thrower (.23) followed by Hammer thrower (.12). However Upper leg length of Discus thrower is negatively correlated (-.38) with his performance.

Lower leg length of Javelin thrower is having greater positive correlation (.46) with performance, than Shot putter (.37) followed by Hammer thrower (.02). However Lower leg length of Discus thrower is negatively (-.32) correlated with his performance.

Total leg length of Hammer thrower is having greater positive correlation (.31) with performance, than Javelin thrower (.26) followed by Shot putter (.08) and Discus thrower (0.05).

Muscles girths of Shot putter is having greater positive correlation (.87) with performance, than Javelin thrower (.32) followed by Hammer thrower (.09). However muscles girths of Discus thrower is negatively (-.33) correlated with his performance.

Skin folds of Shot putter is having greater positive correlation (.55) with performance, than Hammer thrower (.22), followed by Discus thrower (.08), and Javelin thrower (.06).

Endomorphy of Shot putter is having greater correlation (.43) with performance, than Hammer thrower (.15), followed by Discus thrower (.11), and Javelin thrower (.06).

Mesomorphy of Discus thrower is having greater negative correlation (-.33) with performance, than Shot putter (-.22), followed by Hammer thrower (-.09). However Mesomorphy of Javelin thrower is positively correlated (.12) with his performance.

Ectomorphy of Discus thrower is having greater positive correlation (.37) with performance, than Javelin thrower (.25). However ectomorphy of Shot putter is more negatively (-.48) correlated with his performance, than Hammer thrower (-.30).

Sitting height-Stature index of Hammer thrower is having greater positive correlation (.24) with performance, than Discus thrower (.22) followed by Shot putter (.19). However Sitting height-Stature index of Javelin thrower is negatively (-.18) correlated with his performance.

Ponderal index of Discus thrower is having greater positive correlation (.37) with performance, than Javelin thrower (.23). However

ponderal index of Shot putter is more negatively correlated (-.48) with his performance, than Hammer thrower (-.3).

Thigh length-lower leg length index of Hammer thrower is having greater positive correlation (.07) with performance, than Shot putter (.04) followed by Discus thrower (.02). However thigh length-lower leg length index of Javelin thrower is negatively correlated (-.18) with his performance.

Upper arm length-Lower arm length of Shot putter is having greater positive correlation (.38) with performance, than Hammer thrower (.24) followed by Javelin thrower (.23). However Upper arm length-Lower arm length of Discus thrower is negatively correlated (-.30) with his performance.

Hip breadth-Stature index of Discus thrower is having greater negatively correlation (-.46) with performance, than Hammer thrower (-.11) followed by Shot putter (-.06). However hip breadth-Stature index of Javelin thrower is positively (.14) correlated with his performance.

Shoulder breadth-Stature index of Discus thrower is having more negative correlation (-.34) with performance, than Javelin thrower (-.33). However Shoulder breadth-Stature index of Shot putter is more positively correlated (.04) with performance, than Hammer thrower correlation (.02) with his performance.

Fat (%) percentage of Shot putter is having greater positive correlation (.54) with performance, than Javelin thrower (.16) followed by Discus thrower (.09), and Hammer thrower (0.03).

Foot Length of Javelin thrower is having greater negative correlation (-.36) with performance, than Shot putter (-.018), followed by Discus thrower (-.002). However Mesomorphy of Hammer thrower is positively correlated (.207) with his performance.

Results obtained through analysis of variance and LSD test for each of the chosen variable are produced below.

TOTAL AGE

Table-115

Source of Variation	D.f.	ss	mss	F-value
Treatment	r-1=3	26.44	8.813333	1.16
Error	N-r=96	727.92	7.5825	

Significant at .05 level

Tab.F.05 (3,96)=2.70

Since calculated F value is lesser than tabulated F value, we are able to conclude that there is no significant difference in the mean total age of Hammer, Shot put, Discuss and Javelin throwers.

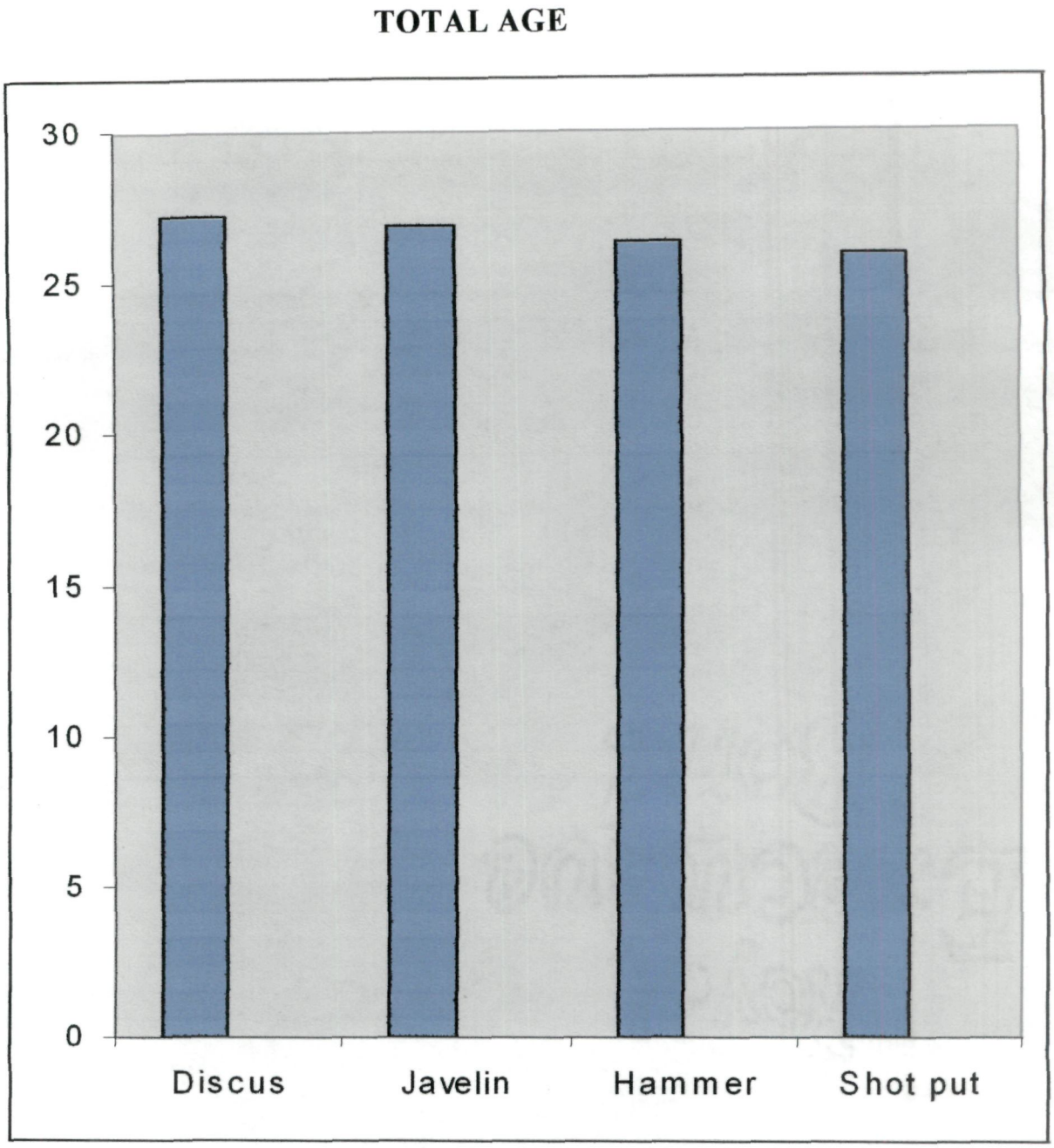


Figure-9; The mean Total Age (in years) of Throwers (Shot putter, Discus thrower, Javelin thrower and Hammer throwers).

Table -116.

WEIGHT

source of variation	D.f.	Ss	Mss	F-value
Treatment	r-1=3	8842.8	2947.6	38.69638
Error	N-r=96	7312.56	76.1725	

*Significant at .05 level

Tab F .05 (3,96) = 2.70

Since calculated F value is greater than tabulated F value, the hypothesis is accepted and we conclude that significant difference is existing in the mean weight of Shot put, Discus, Javelin and Hammer throwers. To further find out which group mean weight is greater than the other, pair wise means analysis is done through LSD test.

Table-117

Treatment means arranged in order of magnitude

Throwing groups				Mean difference	CD at 5% level
Shot put	Discus	Hammer	Javelin		
106.56	92.68			13.88	
106.56			81.04	25.52	4.887
106.56		87.4		19.16	
	92.68		81.04	11.64	
	92.68	87.4		5.28	
		87.4	81.04	6.36	

*Significant at 5% level

Comparing the pair wise mean difference with critical difference we are able to conclude that mean weight of Shot putter is significantly greater than mean weights of Discus, Hammer and Javelin throwers. Further mean weight of Discus thrower is also significantly greater than mean weights of Hammer and Javelin throwers and mean weight of Javelin thrower is significantly the least from all the three groups.

WEIGHT

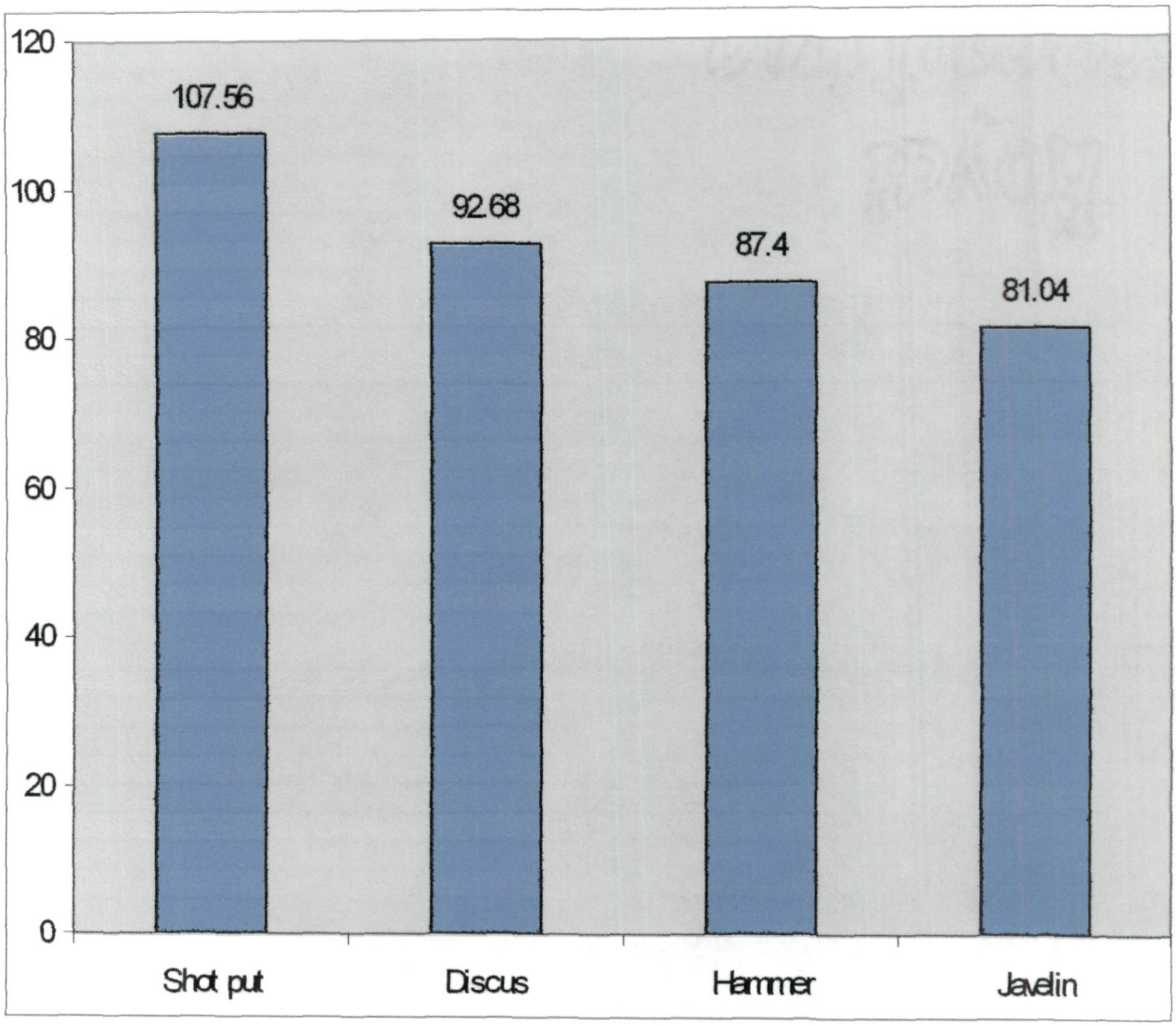


Figure-10; The mean Weight (in Kg.) of Throwers (Shot putter, Discus thrower, Javelin thrower and Hammer throwers).

Table - 118.

HEIGHT

Source of Variation	D.f.	Ss	Mss	F-value
Treatment	r-1=3	806.99	268.9967	9.067558
Error	N-r=96	2847.92	29.66583	

Significant at .05 level

Tab F .05 (3,96) = 2.70

Since calculated F value is greater than tabulated F value, the hypothesis is accepted and we conclude that significant difference is existing in the mean height of Shot put, Discus, Javelin and Hammer throwers .To further find out which group is having greater height, pair wise mean analysis is done through LSD test.

Table-119

Treatment means arranged in order of magnitude

Throwing groups				Mean difference	CD at 5% level
Discus	Shot put	Javelin	Hammer		
183.92	182.68			1.24	
	182.68	178.4		4.28	
	182.68		177.12	5.56	0.610097
183.92		178.4		5.52	
183.92			177.12	6.8	
		178.4	177.12	1.28	

*Significant at 5% level

Comparing the pair wise mean difference with critical difference we are able to conclude that mean height of Discus throwers is significantly greater than mean height of Shot putter, Javelin and Hammer throwers. Further mean height of Shot putter is also significantly greater than mean Height of Javelin and Hammer throwers and mean height of Hammer thrower is significantly the least from all the three groups.

HEIGHT

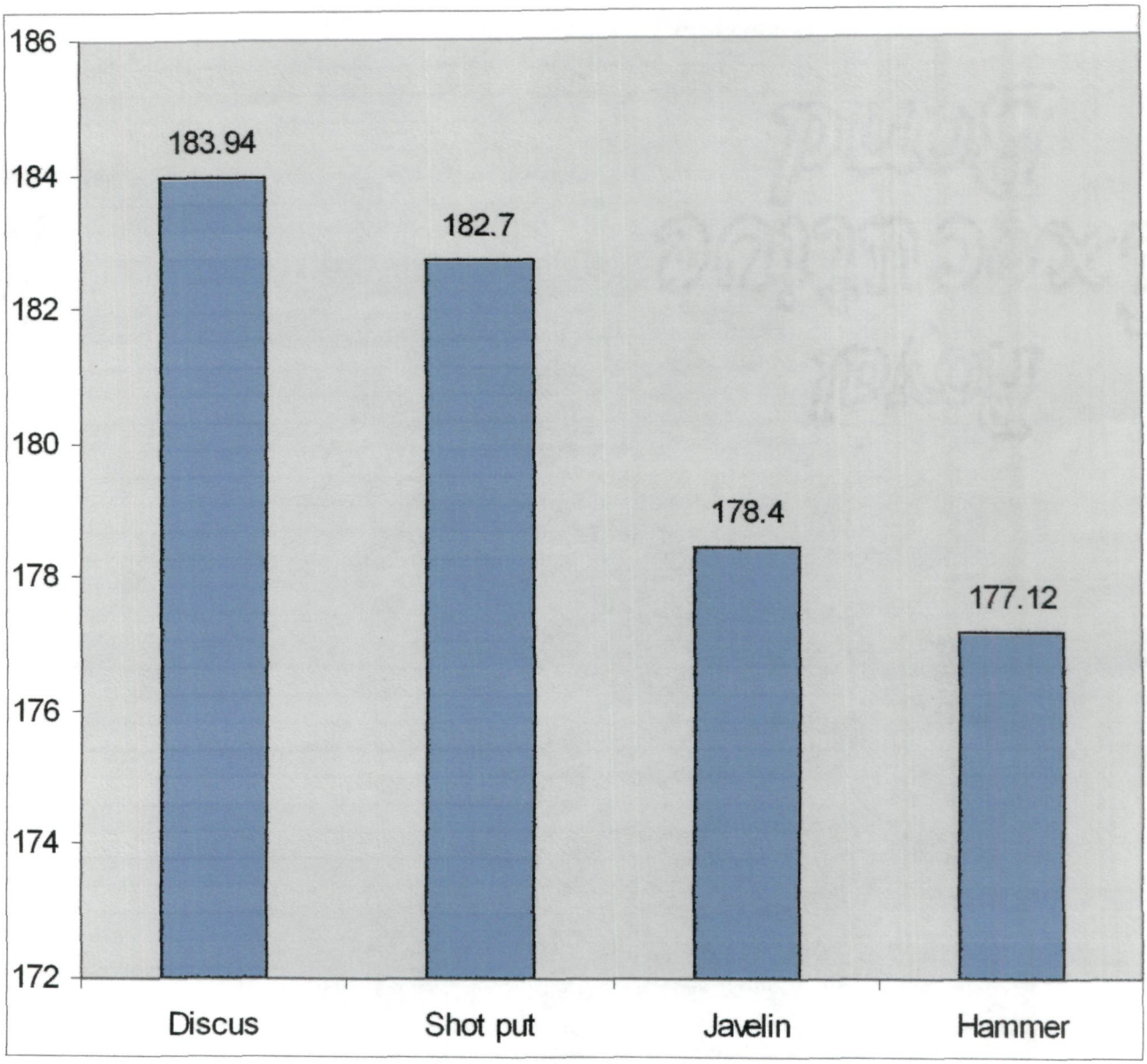


Figure-11; The mean Height (in cm.) of Throwers (Shot putter, Discus thrower, Javelin thrower and Hammer throwers).

Table-120

SITTING HEIGHT

Source of variation	D.f.	Ss	Mss	F-value
Treatment	r-1=3	65.63	21.87667	1.959104
Error	N-r=96	1072	11.16667	

Significant at .05 level

Tab F .05 (3,96) = 2.70

Since calculated F value is lesser than tabulated F value, we are able to conclude that there is no significant difference in the mean sitting height of Hammer, Shot put, Discus and Javelin throwers.

SITTING HEIGHT

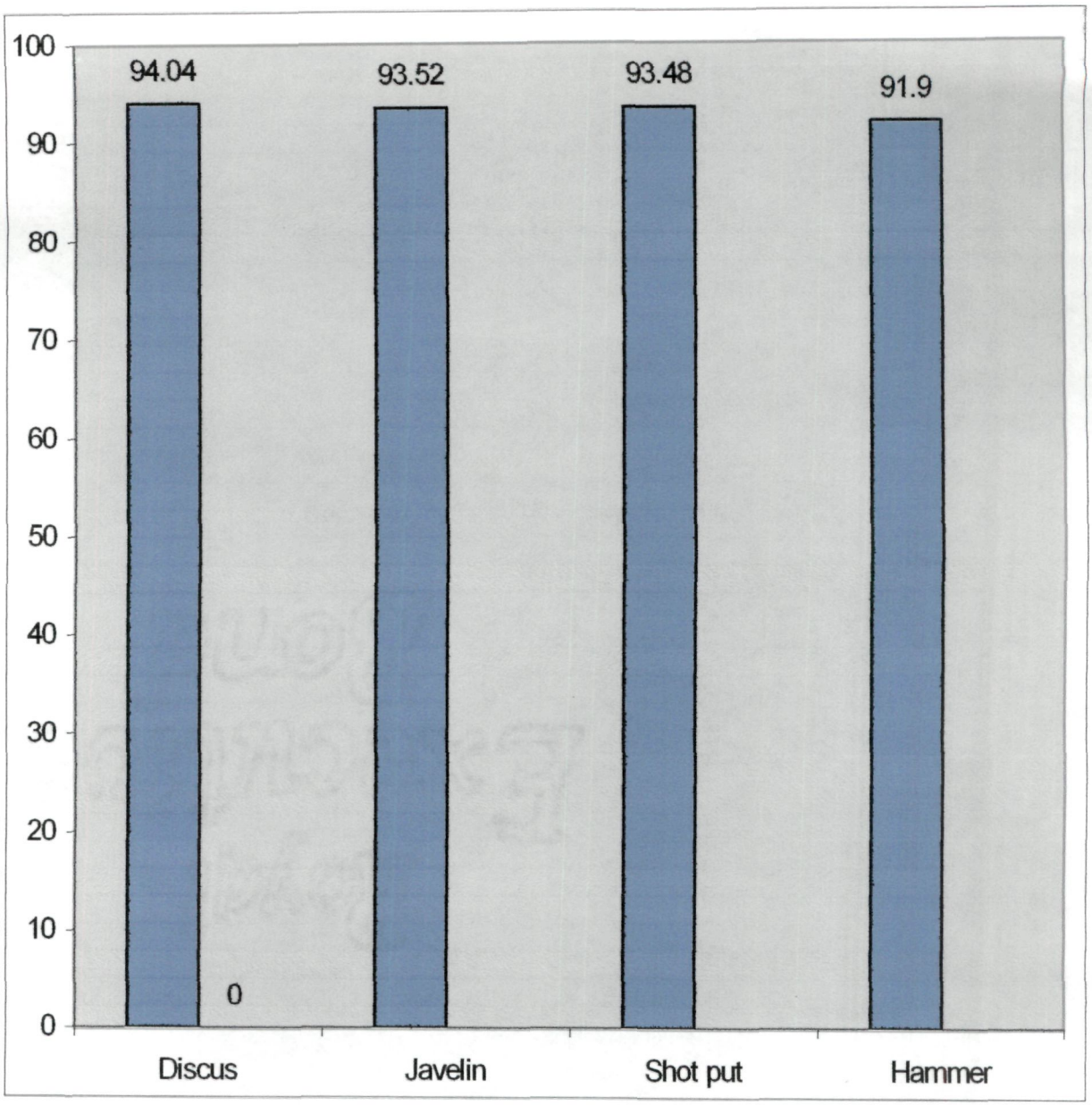


Figure-12; The mean Sitting height (in cm.) of Throwers (Shot putter, Discus thrower, Javelin thrower and Hammer throwers).

Table-121

CHEST GIRTH

source of variation	D.f.	ss	Mss	F-value
Treatment	r-1=3	2909.64	969.88	8.48805
Error	N-r=96	10969.36	114.2642	

*Significant at .05 level

Tab F .05 (3,96) = 2.70

Since calculated F value is greater than tabulated F value, the hypothesis is accepted and we conclude that significant difference is existing in the mean chest girth of Shot put, Discus, Javelin and Hammer throwers. To further find out which group is having greater mean chest girth, pair wise mean analysis is done through LSD test.

Table-122

Treatment means arranged in order of magnitude

Throwing groups				Mean difference	CD at 5% level
Shot put	Hammer	Discus	Javelin		
109.52		98.6		10.92	1.197257
109.52			94.84	14.68	
109.52	100.64			8.88	
		98.6	94.84	3.76	
	100.64	98.6		2.04	
	100.64		94.84	5.8	

*Significant at 5% level

Comparing the pair wise mean difference with critical difference we are able to conclude that mean chest girth of shot putter is significantly greater than mean chest girth of Hammer, Discus and Javelin throwers. Further mean chest girth of Hammer thrower is also significantly greater than mean chest girths of Discus and Javelin throwers and mean chest girth of Javelin thrower is significantly the least from all the three groups.

CHEST GIRTH

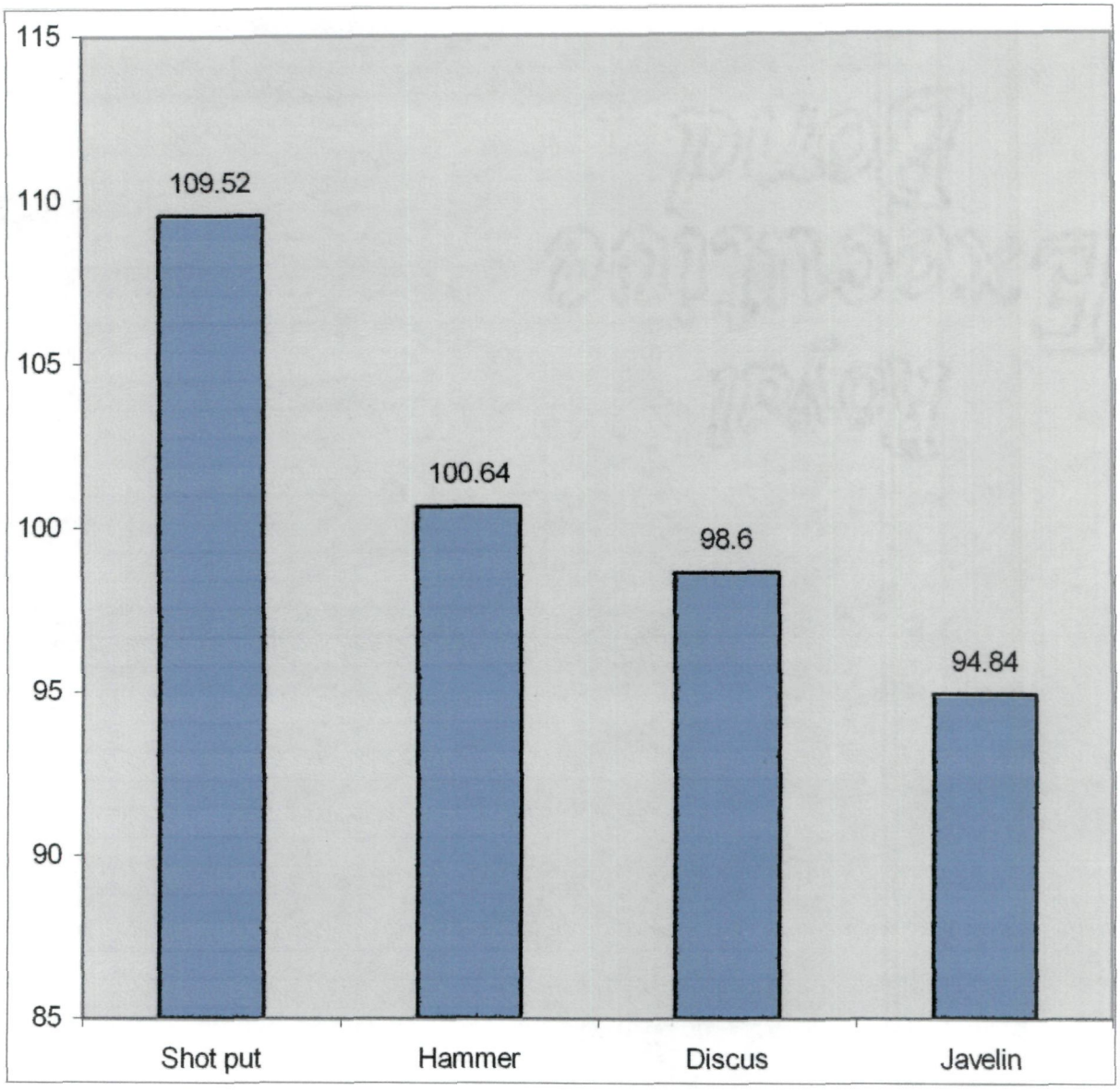


Figure-13; The mean Chest girth (in cm.) of Throwers (Shot putter, Discus thrower, Javelin thrower and Hammer throwers).

Table-123

CHEST DEPTH

source of variation	**D.f.**	**ss**	**mss**	**F-value**
Treatment	r-1=3	131.3003	43.76677	14.1361
Error	N-r=96	297.2256	3.0961	

*Significant at .05 level

Tab F .05 (3, 96) = 2.70

Since calculated F value is greater than tabulated F value, the hypothesis is accepted and we conclude that significant difference is existing in the mean chest depth of Shot put, Discus, Javelin and Hammer throwers. To further find out which group is having greater mean chest depth, pair wise means analysis is done through LSD test.

Table-124

Treatment means arranged in order of magnitude

Throwing groups				Mean difference	CD at 5% level
Shot put	Discus	Hammer	Javelin		
23.64	23.04			0.6	
23.64			20.92	2.72	0.197
23.64		21.28		2.36	
	23.04		20.92	2.12	
		21.28	20.92	0.36	
	23.04	21.28		1.76	

*Significant at 5% level

Comparing the pair wise mean difference with critical difference we are able to conclude that mean chest depth of Shot putter is significantly greater than mean of discus, Hammer and Javelin throwers. Further mean chest depth of Discus thrower is also significantly greater than mean chest depth of Hammer and Javelin throwers and mean chest depth of Javelin thrower is significantly the least from all the three groups.

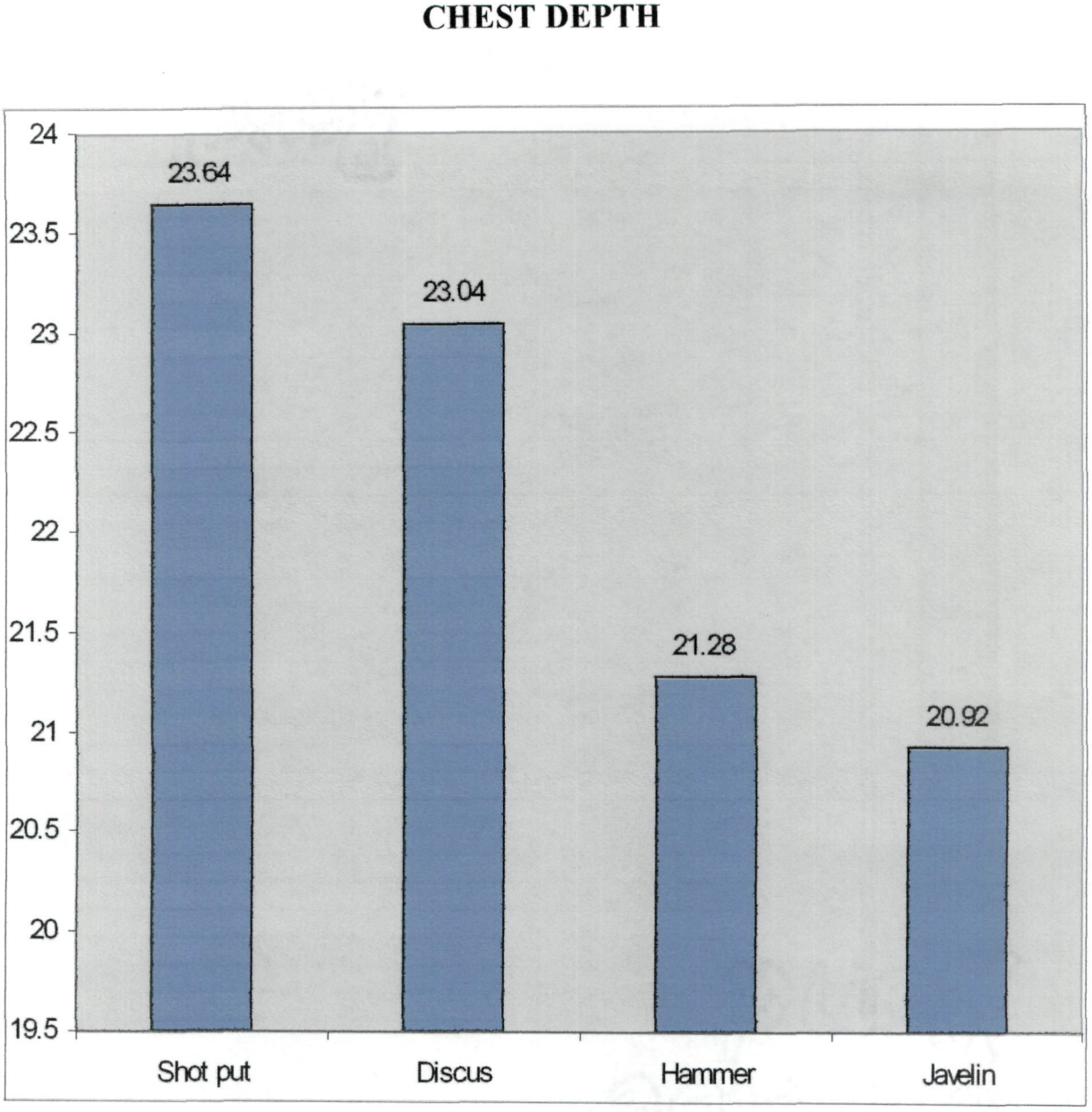


Figure-14; The mean Chest depth (in cm.) of Throwers (Shot putter, Discus thrower, Javelin thrower and Hammer throwers).

Table-125

HUMERUS BIEPICONDYLAR

source of variation	D.f.	ss	mss	F-value
reatment	r-1=3	4.512	1.504	6.474619
Error	N-r=96	22.3	0.232292	

*Significant at .05 level

Tab F .05 (3,96) = 2.70

Since calculated F value is greater than tabulated F value, the hypothesis is accepted and we conclude that significant difference is existing in the mean humerus biepicondylar of Shot put, Discus, Javelin and Hammer throwers. To further find out which group is having greater mean humerus biepicondylar, pair wise means analysis is done through LSD test.

Table-126

Treatment means arranged in order of magnitude

Throwing groups				Mean difference	CD at 5% level
Shot put	Discus	Javelin	Hammer		
7.38	7.04			0.34	
7.38		6.98		0.4	
7.38			6.792	0.59	0.053983
	7.04	6.98		0.06	
		6.98	6.792	0.19	
	7.04		6.792	0.25	

*Significant at 5% level

Comparing the pair wise mean difference with critical difference we are able to conclude that mean humerus biepicondylar of Shot putters is significantly greater than mean humerus biepicondylar of Discus, Hammer and Javelin throwers. Further mean humerus biepicondylar of Discus thrower is also significantly greater than means humerus biepicondylar of Hammer and Javelin throwers however means humerus biepicondylar of Javelin throwers is significantly the least from all the three groups.

HUMERUS BIEPICONDYLAR

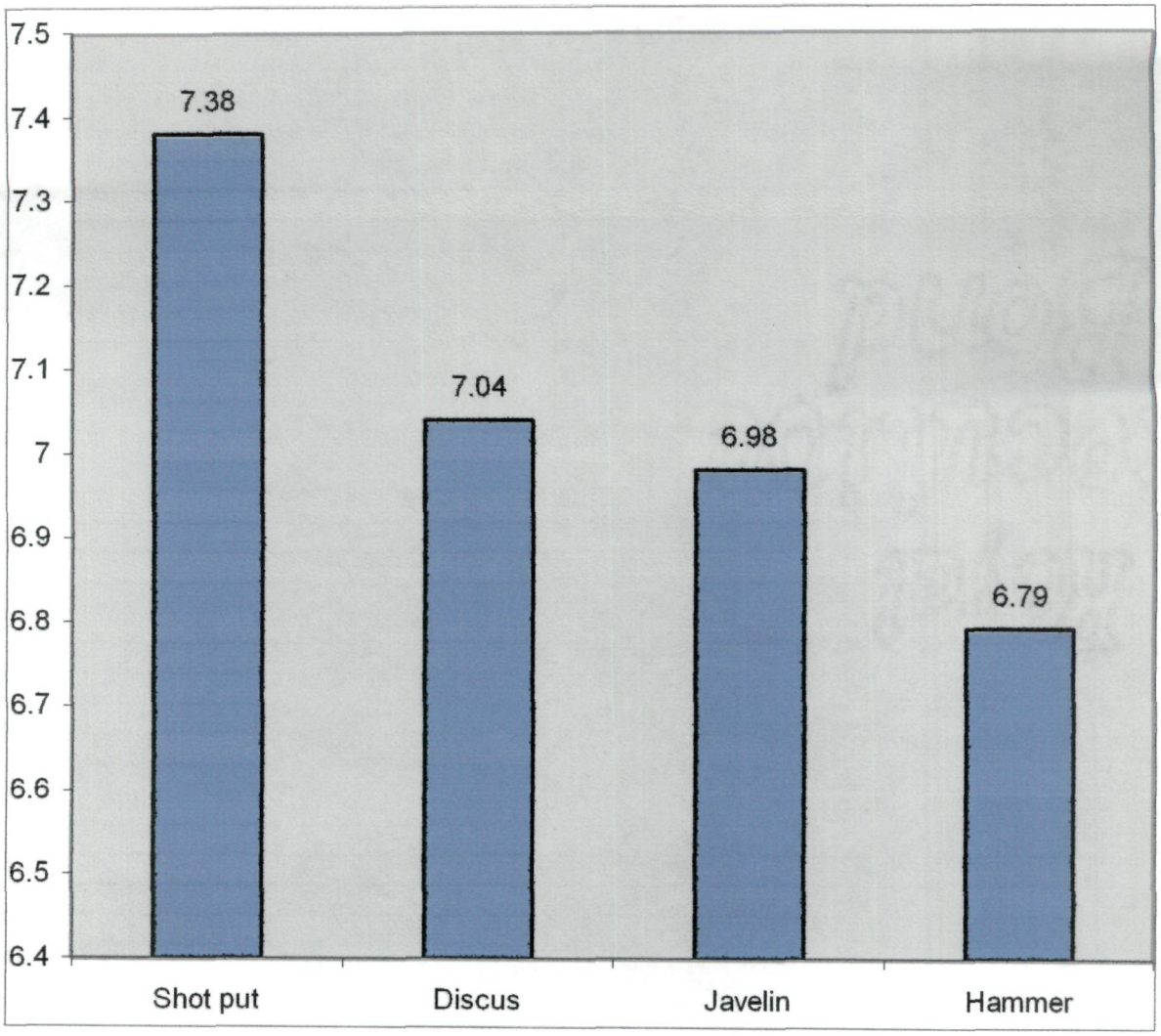


Figure-15; The mean Humerus Biepicondylar (in cm.) of Throwers (Shot putter, Discus thrower, Javelin thrower and Hammer throwers).

Table-127

WRIST BREADTH

Source of variation	D.f.	Ss	mss	F-value
Treatment	r-1=3	6.8923	2.297433	19.05661
Error	N-r=96	11.5736	0.120558	

*Significant at .05 level

Tab F .05 (3,96) = 2.70

Since calculated F value is greater than tabulated F value, the hypothesis is accepted and we conclude that significant difference is existing in the mean wrist breadth of Shot put, Discus, Javelin and Hammer throwers. To further find out which group is having greater mean Wrist breadth, pair wise mean analysis is done through LSD test.

Table-128

Treatment means arranged in order of magnitude

Throwing groups				Mean difference	CD at 5% level
Shot put	Javelin	Discus	Hammer		
6.68		6.12		0.56	
6.68	6.6			0.08	0.0388
6.68			6.11	0.56	
	6.6	6.12		0.48	
	6.6		6.11	0.48	
		6.12	6.11	0.01	

*Significant at 5% level

Comparing the pair wise mean difference with critical difference we are able to conclude that mean wrist breadth of Shot putter is significantly greater than mean wrist breadths of Javelin, Discus and Hammer throwers. Further mean wrist breadth of Javelin thrower is also significantly greater than mean wrist breadth of Discus and Hammer throwers and mean wrist breadth of hammer thrower is significantly the least from all the three groups.

WRIST BREADTH

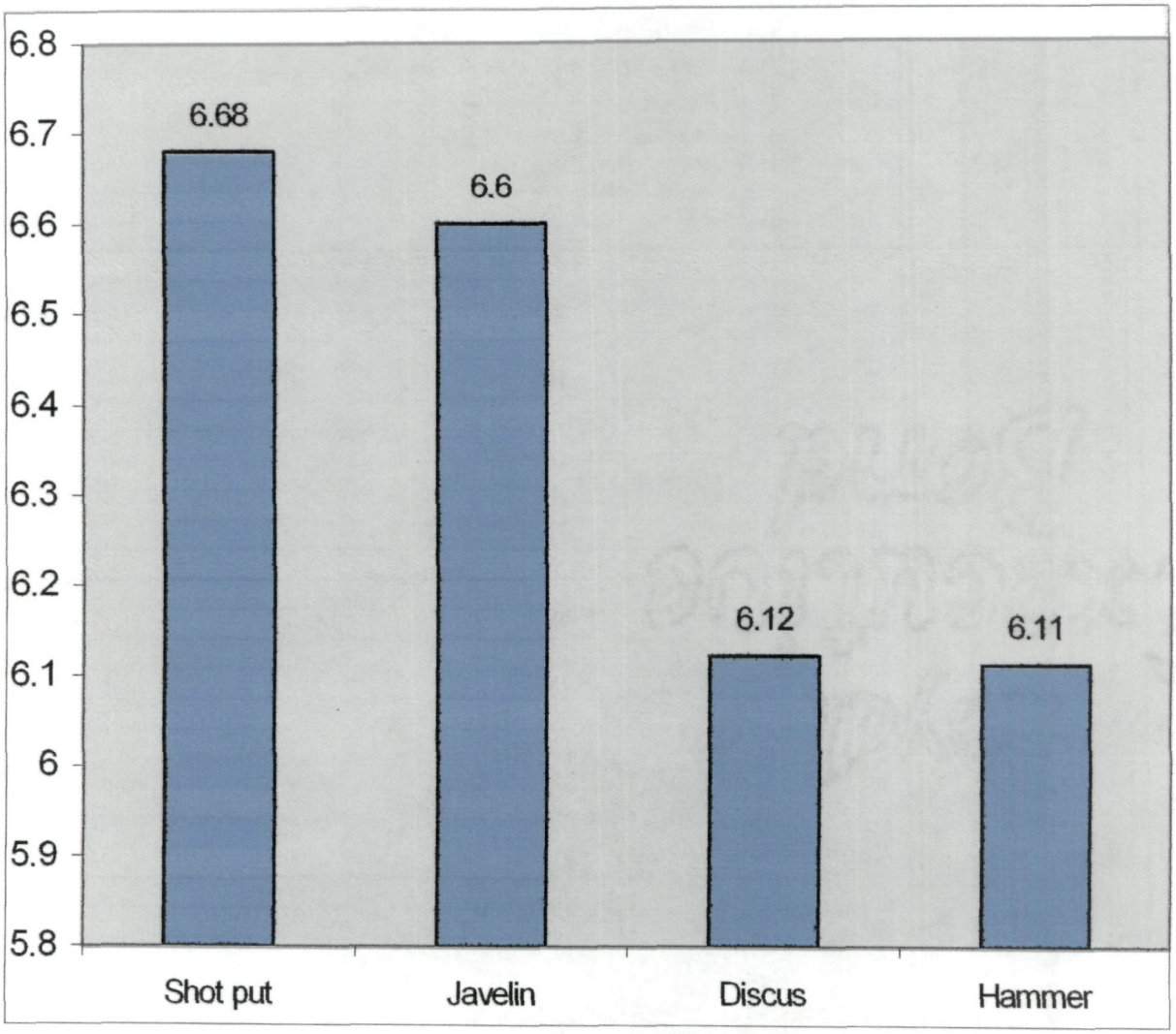


Figure-16; The mean Wrist breadth (in cm.) of Throwers (Shot putter, Discus thrower, Javelin thrower and Hammer throwers).

Table-129

HIP BREADTH

Source of variation	D.f.	Ss	mss	F- Value
Treatment	r-1=3	597.71	199.2367	24.39384
Error	N-r=96	784.08	8.1675	

*Significant at .05 level

Tab F .05 (3,96) = 2.70

Since calculated F value is greater than tabulated F value, the hypothesis is accepted and we conclude that significant difference is existing in the mean hip breadth of Shot putters and Discus, Javelin and Hammer throwers. To further find out which group is having greater mean hip breadth, pair wise mean analysis is done through LSD test.

Table-130

Treatment means arranged in order of magnitude

Throwing groups				Mean difference	CD at 5% level
Shot put	Discus	Javelin	Hammer		
37.4	34.12			3.28	
37.4		31.6		5.8	0.320148
37.4			31.32	6.08	
	34.12	31.6		2.52	
		31.6	31.32	0.28	
	34.12		31.32	2.8	

*Significant at 5% level

Comparing the pair wise mean difference with critical difference we are able to conclude that mean hip breadth of Shot putter is significantly greater than mean hip breadth of Discus, Javelin and Hammer throwers. Further mean hip breadth of Discus thrower is also significantly greater than mean hip breadth of Javelin and Hammer throwers and mean hip breadth of Hammer thrower is significantly the least from all the three groups.

HIP BREADTH

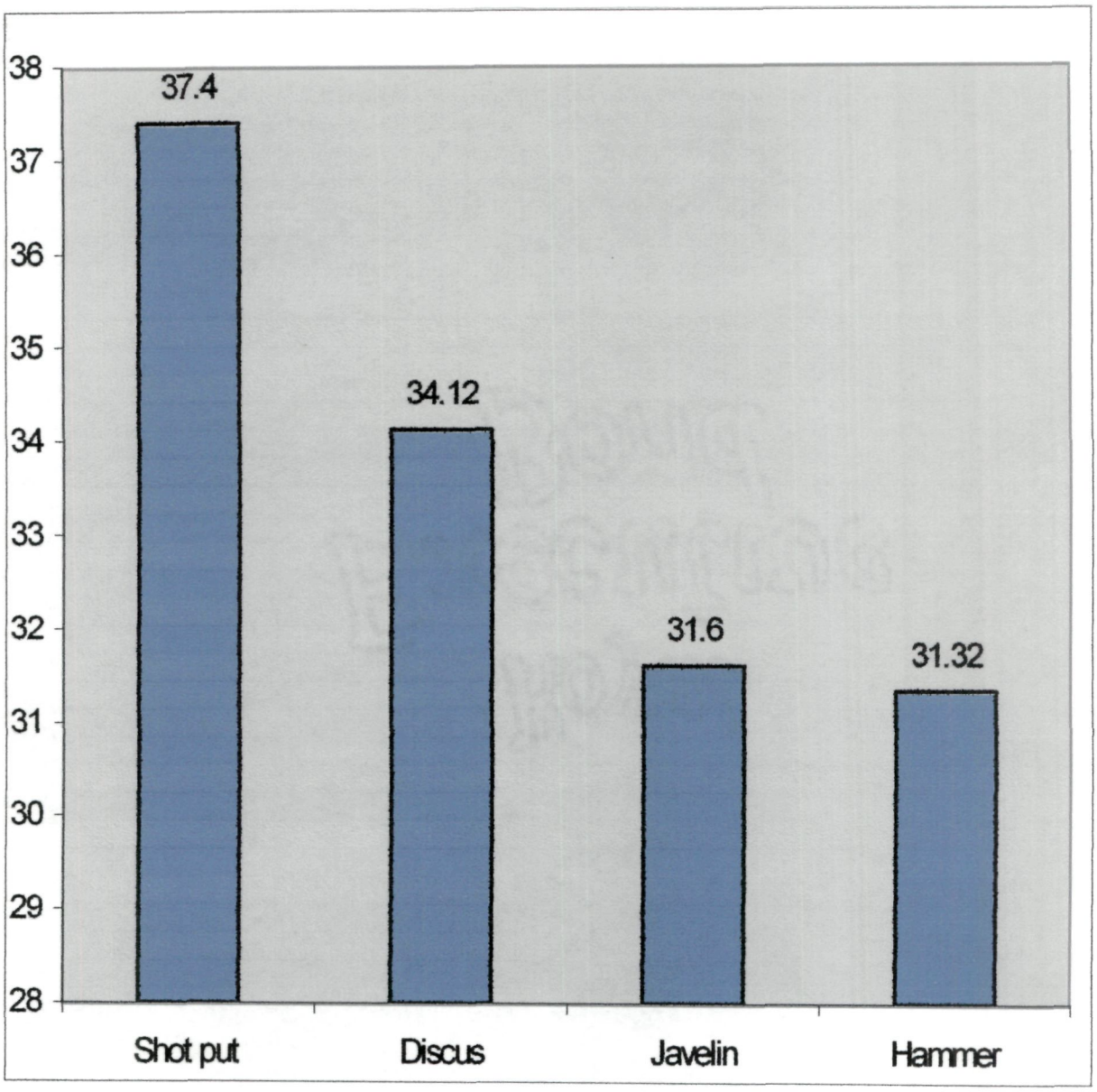


Figure-17; The mean Hip breadth (in cm.) of Throwers (Shot putter, Discus thrower, Javelin thrower and Hammer throwers).

Table-131

SHOULDER BREADTH

source of variation	D.f.	ss	mss	F-value
Treatment	r-1=3	72.44	24.14667	3.086165
Error	N-r=96	751.12	7.824167	

*Significant at .05 level

Tab F .05 (3,96) = 2.70

Since calculated F value is greater than tabulated F value, the hypothesis is accepted and we conclude that significant difference is existing in the mean Shoulder breadth of Shot put, Discus, Javelin and Hammer throwers .To further find out which group is having greater mean Shoulder breadth, pair wise mean analysis is done through LSD test.

Table-132

Treatment means arranged in order of magnitude

Throwing groups				Mean difference	CD at 5% level
Shot put	Javelin	Hammer	Discus		
41.76			39.36	2.4	
41.76	40.72			1.04	0.313216
41.76		40.64		1.12	
	40.72		39.36	1.36	
	40.72	40.64		0.08	
		40.64	39.36	1.28	

*Significant at 5% level

Comparing the pair wise mean difference with critical difference we are able to conclude that mean Shoulder breadth of Shot putter is significantly greater than mean Shoulder breadth of Javelin, Hammer and Discus throwers. Further mean Shoulder breadth of Javelin thrower is also significantly greater than mean Shoulder breadth of Hammer and Discus throwers and mean Shoulder breadth of Discus thrower is significantly the least from all the three groups.

SHOULDER BREADTH

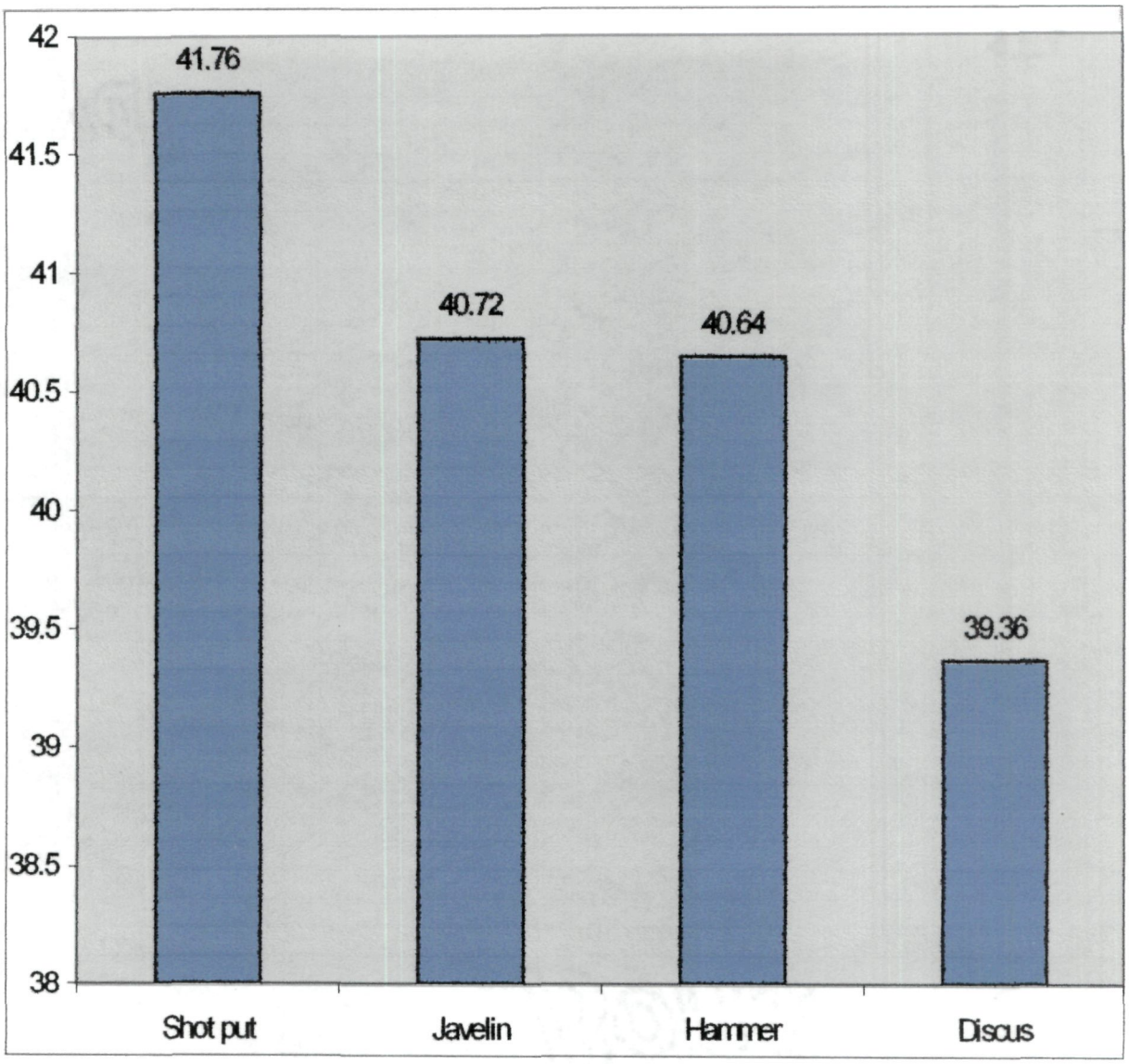


Figure-18; The mean Shoulder breadth (in cm.) of Throwers (Shot putter, Discus thrower, Javelin thrower and Hammer throwers).

TABLE-133

TOTAL ARM LENGTH

source of variance	D.f.	ss	mss	F-value
Treatment	r-1=3	125.55	41.85	4.176994
Error	N-r=96	961.84	10.01917	

*Significant at .05 level

Tab F .05 (3, 96) = 2.70

Since calculated F value is greater than tabulated F value, the hypothesis is accepted and we conclude that significant difference is existing in the mean total arm length of Shot putter and Discus, Javelin and Hammer throwers .To further find out which group is having greater mean total arm length, pair wise mean analysis is done through LSD test.

Table-134

Treatment means arranged in order of magnitude

Throwing groups				Mean difference	CD at 5% level
Javelin	Discus	Shot put	Hammer		
	80.12	78.68		1.44	
80.36		78.68		1.68	0.3545
		78.68	77.6	1.08	
80.36	80.12			0.24	
80.36			77.6	2.76	
	80.12		77.6	2.52	

*Significant at 5% level

Comparing the pair wise mean difference with critical difference we are able to conclude that mean total arm length of Javelin throwers is significantly greater than mean total arm length of Discus throwers, Shot putter and Hammer throwers. Further mean total arm length of Discus thrower is also significantly greater than mean total arm length of Shot putter and Hammer throwers and mean total arm length of Hammer thrower is significantly the least from all the three groups.

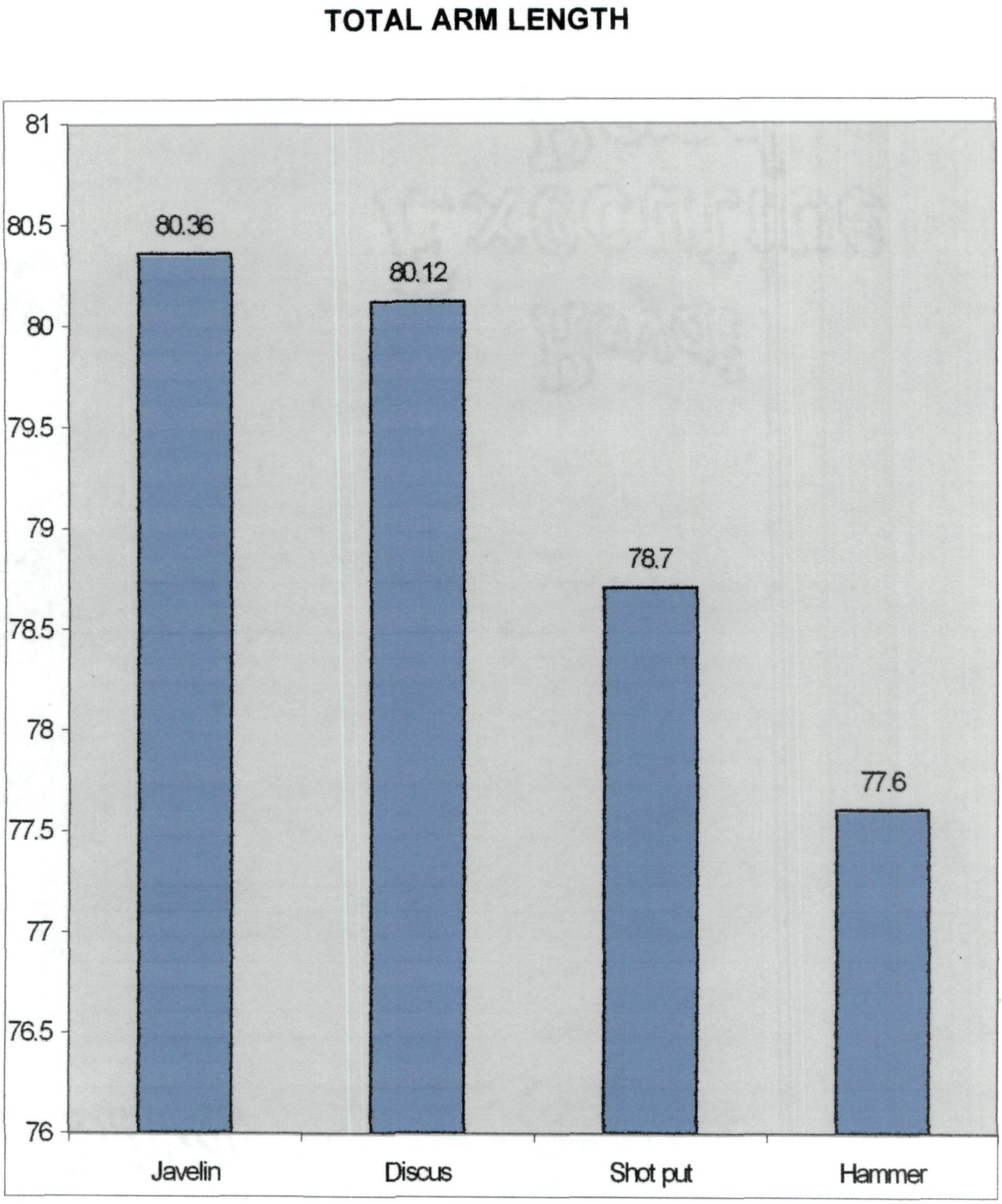


Figure-19; The mean Total arm length (in cm.) of Throwers (Shot putter, Discus thrower, Javelin thrower and Hammer throwers).

TABLE-135

TOTAL LEG LENGTH

source of variation	D.f.	ss	mss	F-value
Treatment	r-1=3	790.27	263.4233	7.911403
Error	N-r=96	3196.48	33.29667	

*Significant at .05 level

Tab F .05 (3,96) = 2.70

Since calculated F value is greater than tabulated F value, the hypothesis is accepted and we conclude that significant difference is existing in the mean total leg length of Shot put, Discus, Javelin and Hammer throwers. To further find out which group is having greater mean total leg length, pair wise means analysis is done through LSD test.

Table-136

Treatment means arranged in order of magnitude

Throwing groups				Mean difference	CD at 5% level
Discus	Hammer	Javelin	Shot put		
110.6			103.4	7.2	
		104.08	103.4	0.68	0.64631
	106.12		103.4	2.72	
110.6		104.08		6.52	
	106.12	104.08		2.04	
110.6	106.12			4.48	

*Significant at 5% level

Comparing the pair wise mean difference with critical difference we are able to conclude that mean of Discus throwers is significantly greater than mean total leg length of Hammer, Javelin throwers and Shot putter. Further mean total leg length of Hammer thrower is also significantly greater than mean total leg length of Javelin throwers followed by Shot putter mean total leg length of shot putters.

TOTAL LEG LENGTH

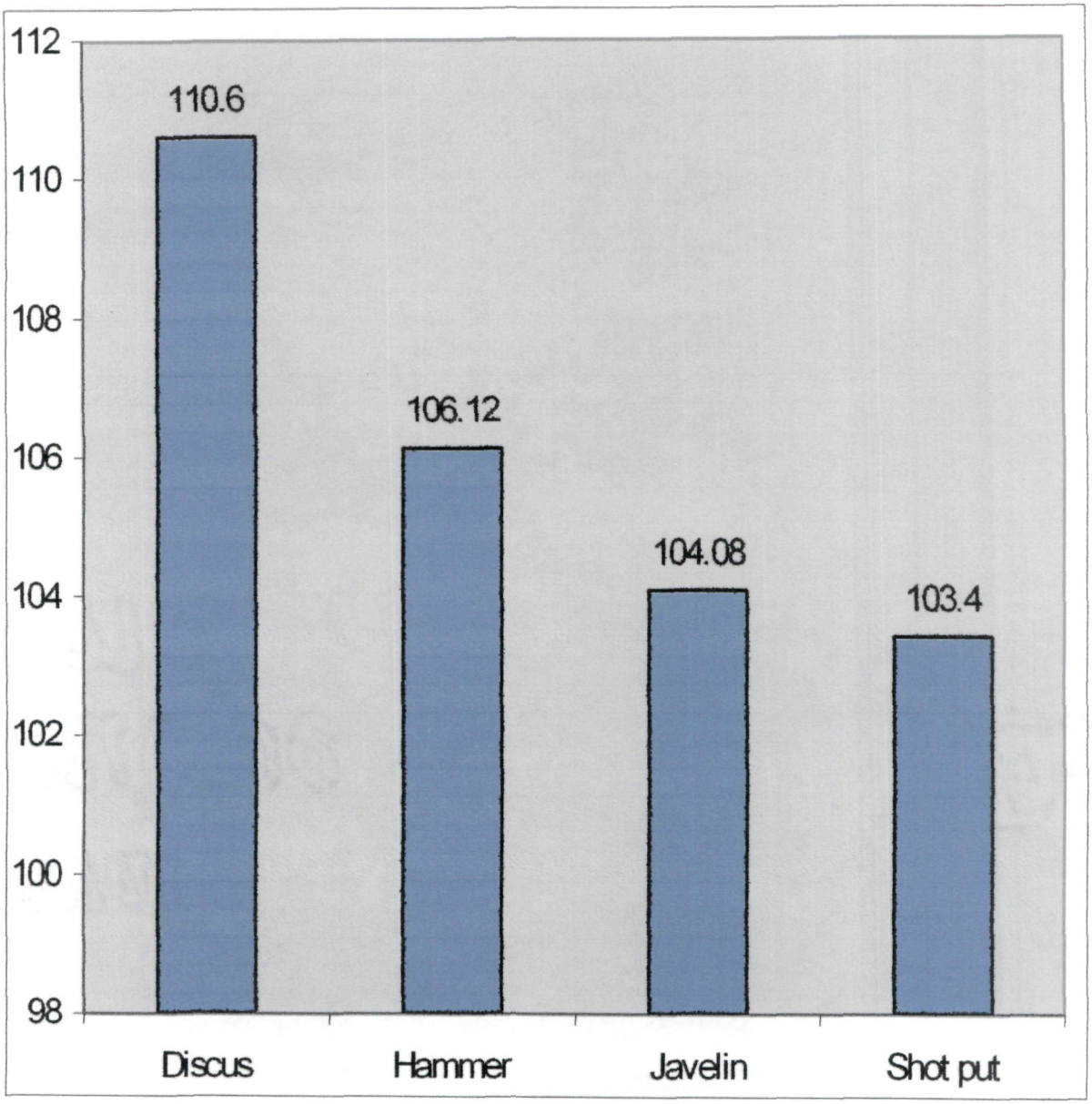


Figure-20; The mean Total leg length (in cm.) of Throwers (Shot putter, Discus thrower, Javelin thrower and Hammer throwers).

TABLE-137
BICEPS MUSCLES GIRTH

Source of variation	D.f.	SS	mss	F-value
Treatment	r-1=3	1339.79	446.5967	40.9596
Error	N-r=96	1046.72	10.90333	

*Significant at .05 level
Tab F .05 (3,96) = 2.70

Since calculated F value is greater than tabulated F value, the hypothesis is accepted and we conclude that significant difference is existing in the mean biceps muscle of Shot put, Discus, Javelin and Hammer throwers. To further find out which group is having greater mean biceps muscle girth, pair wise mean analysis is done through LSD test.

Table-138
Treatment means arranged in order of magnitude

Throwing groups				Mean difference	CD at 5% level
Shot put	Discus	Hammer	Javelin		
41.12	36.56			4.56	
41.12		32.76		8.36	
41.12			31.84	9.28	0.36984
	36.56	32.76		3.8	
		32.76	31.84	0.92	
	36.56		31.84	4.72	

*Significant at 5% level
Comparing the pair wise mean difference with critical difference we are able to conclude that mean biceps muscle girth of Shot putter throwers is significantly greater than mean of Discus, Hammer and Javelin throwers. Further mean biceps muscle girth of Discus thrower is also significantly greater than mean biceps muscle girth of Hammer and Javelin throwers and mean biceps muscle girth of Javelin thrower is significantly the least from all the three groups.

BICEPS MUSCLES GIRTH

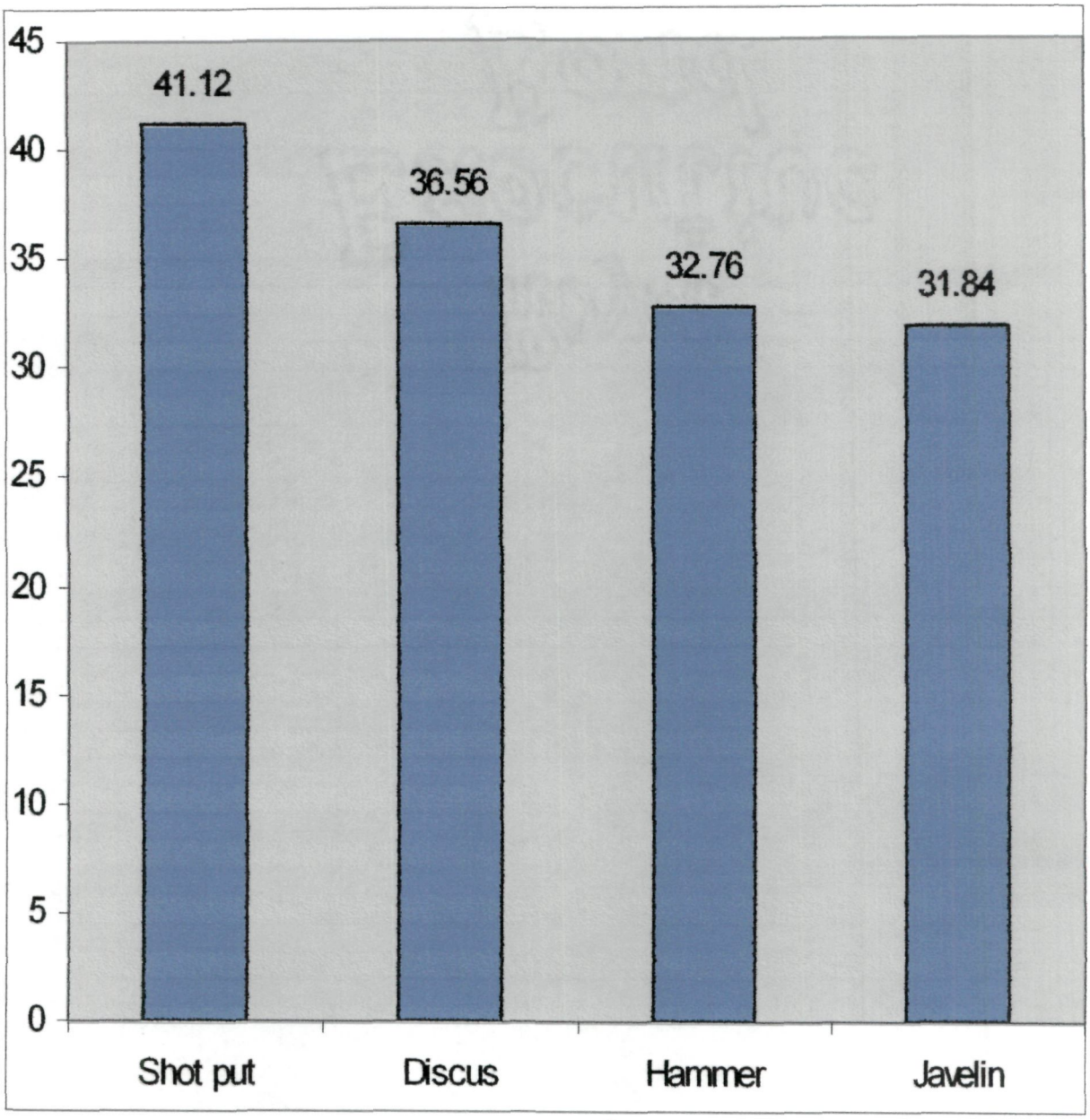


Figure-21; The mean Biceps muscle girth (in cm.) of Throwers (Shot Putter, Discus thrower, Javelin thrower and Hammer throwers).

TABLE-139

SKIN FOLDS

source of variation	D.f.	SS	mss	F-value
Treatment	r-1=3	6383.77	2127.923	8.288421
Error	N-r=96	24646.51	256.7345	

*Significant at .05 level

Tab F .05 (3,96) = 2.70

Since calculated F value is greater than tabulated F value, the hypothesis is accepted and we conclude that significant difference is existing in the mean Skin folds of Shot put, Discus, Javelin and Hammer throwers. To further find out which group is having greater mean Skin folds, pair wise means analysis is done through LSD test.

Table-140

Treatment means arranged in order of magnitude

Throwing groups				Mean difference	CD at 5% level
Shot put	Hammer	Discus	Javelin		
80.4		69.88		10.52	
80.4			58.124	22.28	1.79466
80.4	72.52			7.88	
		69.88	58.124	11.75	
	72.52		58.124	14.39	
	72.52	69.88		2.64	

*Significant at 5% level

Comparing the pair wise mean difference with critical difference we are able to conclude that mean skin folds of Shot putter is significantly greater than mean skin folds of Hammer, Discus and Javelin throwers. Further mean skin folds of Hammer thrower is also significantly greater than mean skin folds of Discus and Javelin throwers and mean skin folds of Javelin thrower is significantly the least from all the three groups.

SKIN FOLD

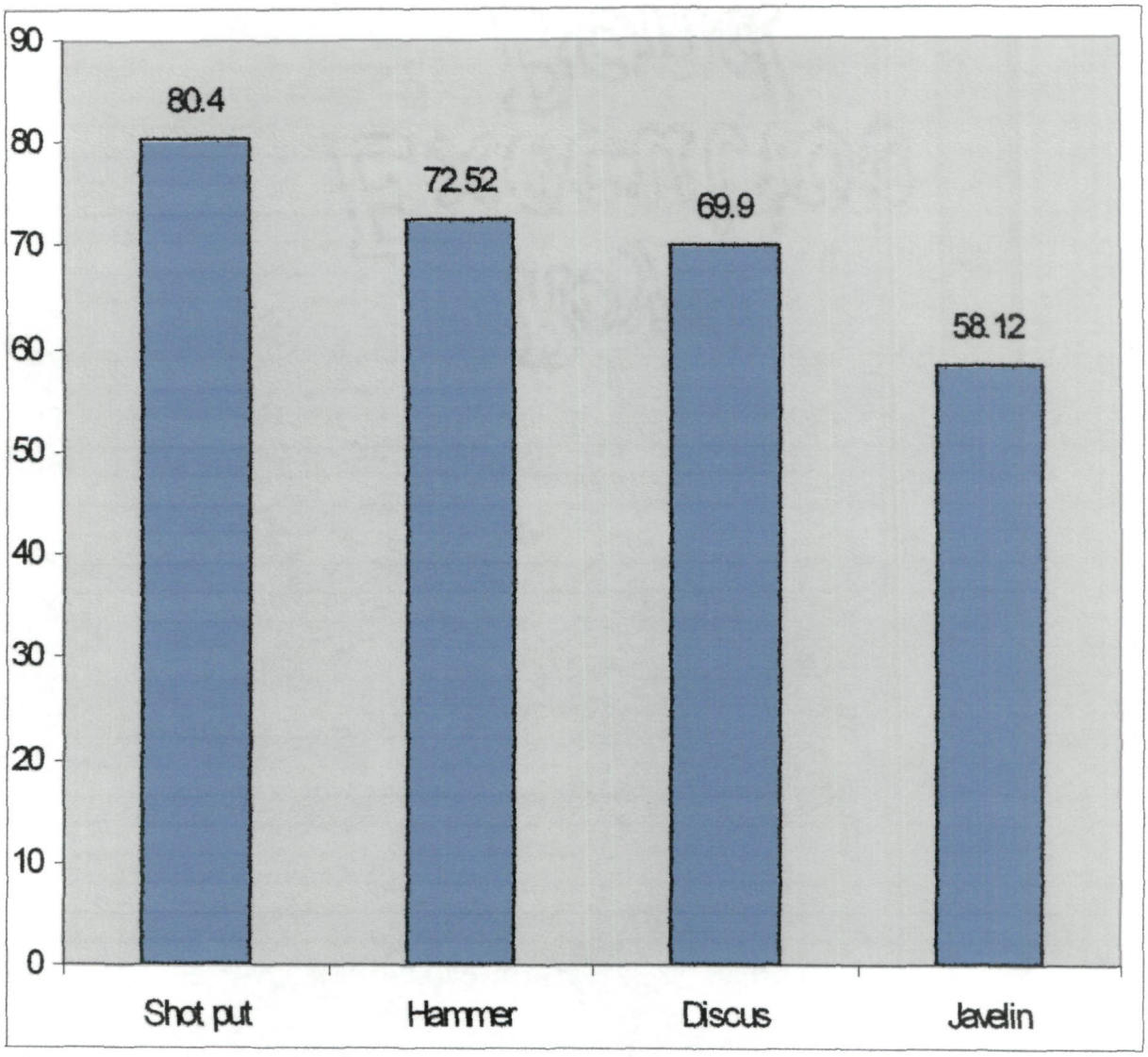


Figure-22; The mean Skin fold of Throwers (Shot putter, Discus thrower, Javelin thrower and Hammer throwers).

Table-141

THIGH MUSCLES GIRTH

source of variation	D.f.	SS	mss	F-value
Treatment	r-1=3	6383.77	2127.923	8.288421
Error	N-r=96	24646.51	256.7345	

*Significant at .05 level

Tab F .05 (3,96) = 2.70

Since calculated F value is greater than tabulated F value, the hypothesis is accepted and we conclude that significant difference is existing in the mean thigh muscle girth of Shot put, Discus, Javelin and Hammer throwers. To further find out which group is having greater mean thigh muscle girth, pair wise means analysis is done through LSD test.

Table-142

Throwing groups				Mean difference	CD at 5% level
Shot put	Discus	Javelin	Hammer		
67.96	64			3.96	
67.96			60.64	7.32	
67.96		63.44		4.52	0.396475
	64		60.64	3.36	
		63.44	60.64	2.8	
	64			0.56	

*Significant at 5% level

Comparing the pair wise mean difference with critical difference we are able to conclude that mean thigh muscle girth of Shot putter is significantly greater than mean thigh muscle girth of Discus and Javelin, Hammer throwers. Further mean thigh muscle girth of Discus thrower is also significantly greater than mean thigh muscle girth of Javelin and Hammer throwers and mean thigh muscle girth of Hammer thrower is significantly the least from all the three groups.

THIGH MUSCLES GIRTH

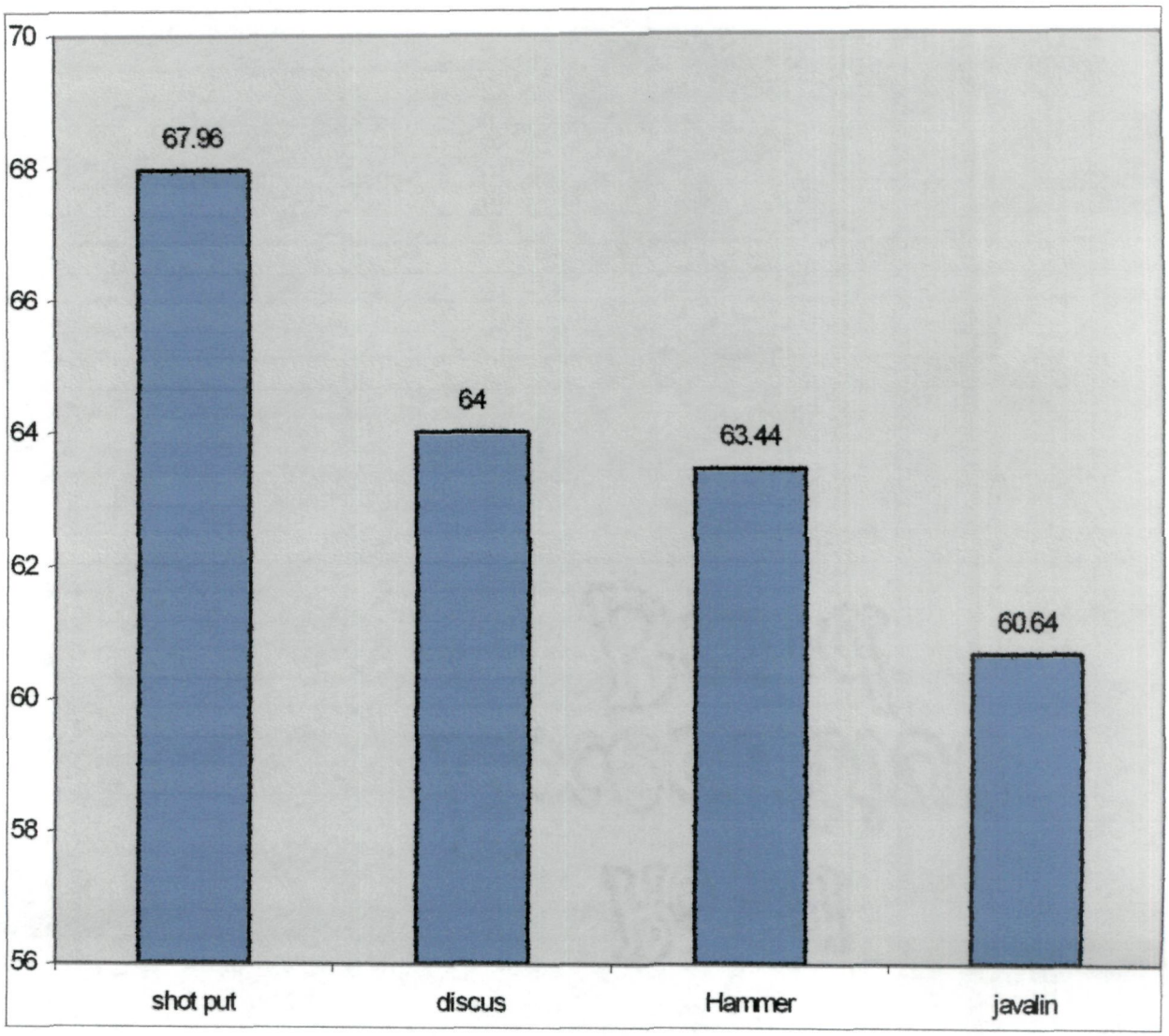


Figure-23; The mean Thigh muscles girth (in cm.) of Throwers (Shot putter, Discus thrower, Javelin thrower and Hammer throwers).

TABLE-143

CALF MUSCLE GIRTH

source of variation	D.f.	SS	mss	F-value
Treatment	r-1=3	3307.87	1102.623	28.59748
Error	N-r=96	3701.44	38.55667	

*Significant at .05 level

Tab F .05 (3,96) = 2.70

Since calculated F value is greater than tabulated F value, the hypothesis is accepted and we conclude that significant difference is existing in the mean Calf muscle girth of Shot put, Discus, Javelin and Hammer thrower. To further find out which group is having greater Calf muscle girth, pair wise mean analysis is done through LSD test.

Table-144

Treatment means arranged in order of magnitude

Throwing groups				Mean difference	CD at 5% level
Shot put	Discus	Hammer	Javelin		
43.48	40.44			3.04	
43.48		35.6		7.88	
43.48			35.36	8.12	0.695488
		35.6	35.36	0.24	
	40.44		35.36	5.08	
	40.44	35.6		4.84	

*Significant at 5% level

Comparing the pair wise mean difference with critical difference we are able to conclude that mean calf muscle girth of Shot putter is significantly greater than mean calf muscle girth of Discus and Hammer, Javelin throwers. Further mean calf muscle girth of Discus thrower is also significantly greater than mean calf muscle girth of Hammer and Javelin throwers and mean calf muscle girth of Javelin thrower is significantly the least from all the three groups.

CALF MUSCLES GIRTH

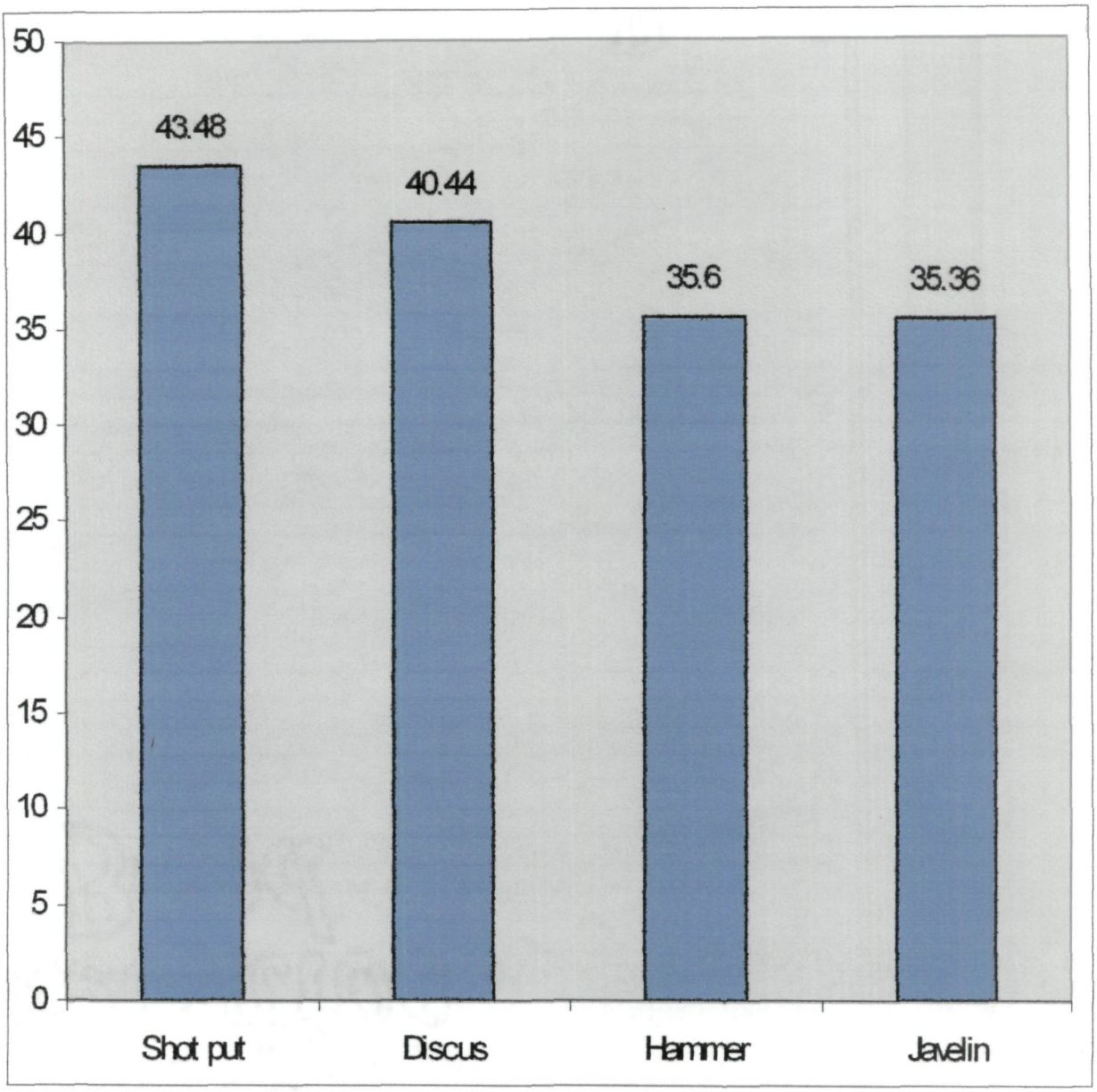


Figure-24; The mean Calf muscles girth (in cm.) of Throwers (Shot putter, Discus thrower, Javelin thrower and Hammer throwers).

Table-145

FOREARM MUSCLE GIRTH

source of variation	D.f.	SS	mss	F-value
Treatment	r-1=3	177.2	59.06667	10.37015
Error	N-r=96	546.8	5.695833	

*Significant at .05 level

Tab F .05 (3,96) = 2.70

Since calculated F value is greater than tabulated F value, the hypothesis is accepted and we conclude that significant difference is existing in the mean forearm muscle girth of Shot put, Discus, Javelin and Hammer throwers. To further find out which group is having greater mean forearm muscle girth, pair wise means analysis is done through LSD test.

Table-146

Treatment means arranged in order of magnitude

Throwing groups				Mean difference	CD at 5% level
Discus	Shot put	Hammer	Javelin		
33.04	32.76			0.28	
33.04		30.68		2.36	0.267312
33.04			29.92	3.12	
		30.68	29.92	0.76	
	32.76		29.92	2.84	
	32.76	30.68		2.08	

*Significant at 5% level

Comparing the pair wise mean difference with critical difference we are able to conclude that mean forearm muscle girth of Discus throwers is significantly greater than mean forearm muscle girth of Shot putters and Hammer, Javelin throwers. Further mean forearm muscle girth of Shot putter is also significantly greater than mean forearm muscle girth of Hammer and Javelin throwers and mean forearm muscle girth of Javelin thrower is significantly the least from all the three groups.

FOREARM MUSCLES GIRTH

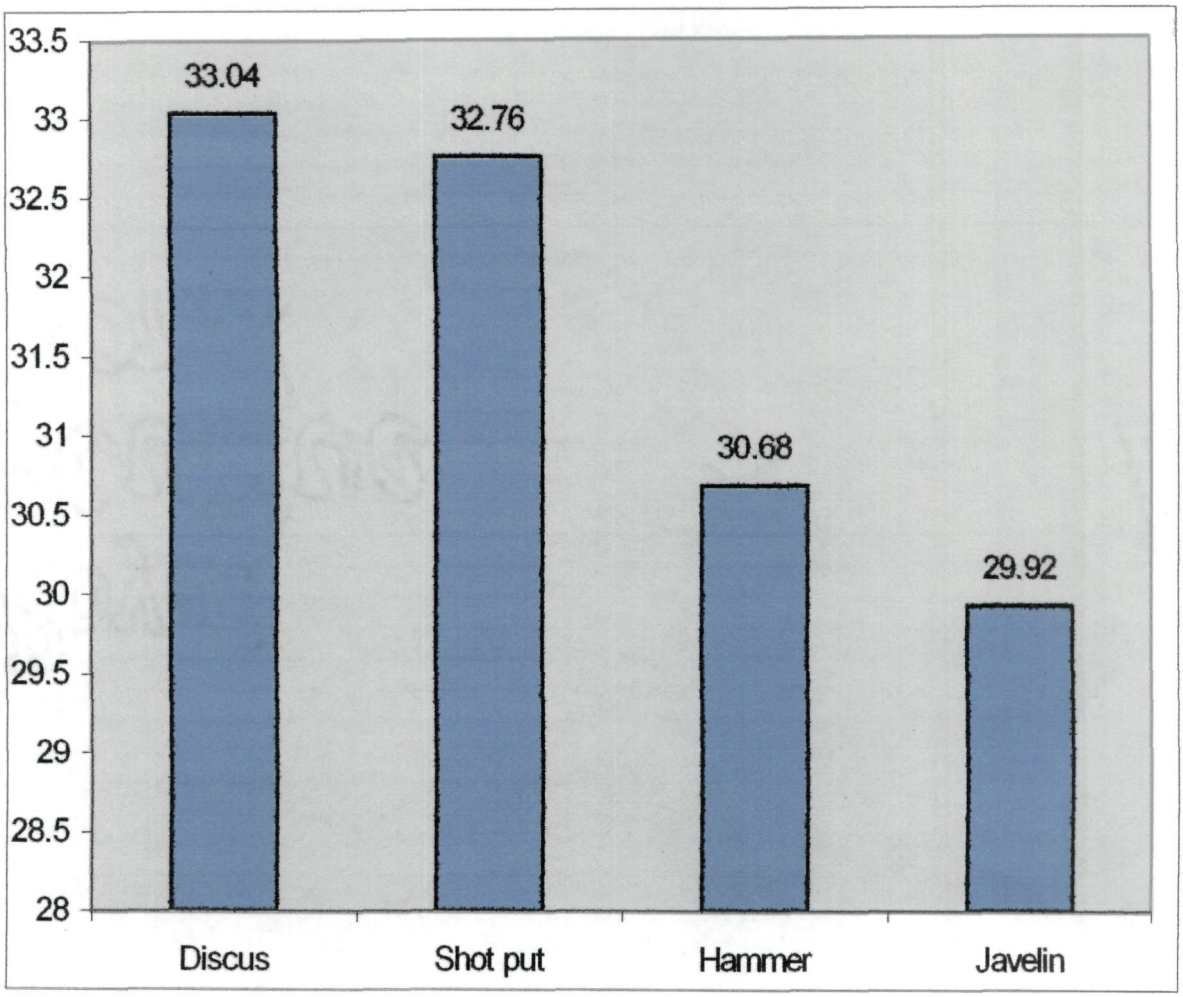


Figure-25; The mean Forearm muscle girth (in cm.) of Throwers (Shot putter, Discus thrower, Javelin thrower and Hammer throwers).

Table-147

FEMUR BIEPICONDYLAR

source of variation	D.f.	SS	mss	F-value
Treatment	r-1=3	12.33	4.11	9.718227
Error	N-r=96	40.6	0.422917	

*Significant at .05 level

Tab F .05 (3, 96) = 2.70

Since calculated F value is greater than tabulated F value, the hypothesis is accepted and we conclude that significant difference is existing in the mean femur biepicondylar of Shot put, Discus, Javelin and Hammer throwers. To further find out which group is having greater mean femur biepicondylar, pair wise means analysis is done through LSD test.

Table-148

Treatment means arranged in order of magnitude

Throwing groups				Mean difference	CD at 5% level
Shot put	Discus	Hammer	Javelin		
9.84	9.82			0.02	
9.84		9.62		0.22	
9.84			9.44	0.4	0.072838
		9.62	9.44	0.18	
	9.82		9.44	0.38	
	9.82	9.62		0.2	

*Significant at 5% level

Comparing the pair wise mean difference with critical difference we are able to conclude that mean femur biepicondylar of Shot putter is significantly greater than mean femur biepicondylar of Discus, Hammer and Javelin throwers. Further mean femur biepicondylar of Discus is also significantly greater than mean femur biepicondylar of Hammer and Javelin throwers and mean femur biepicondylar of Javelin thrower is significantly the least from all the three groups.

FEMUR BIEPICONDYLAR

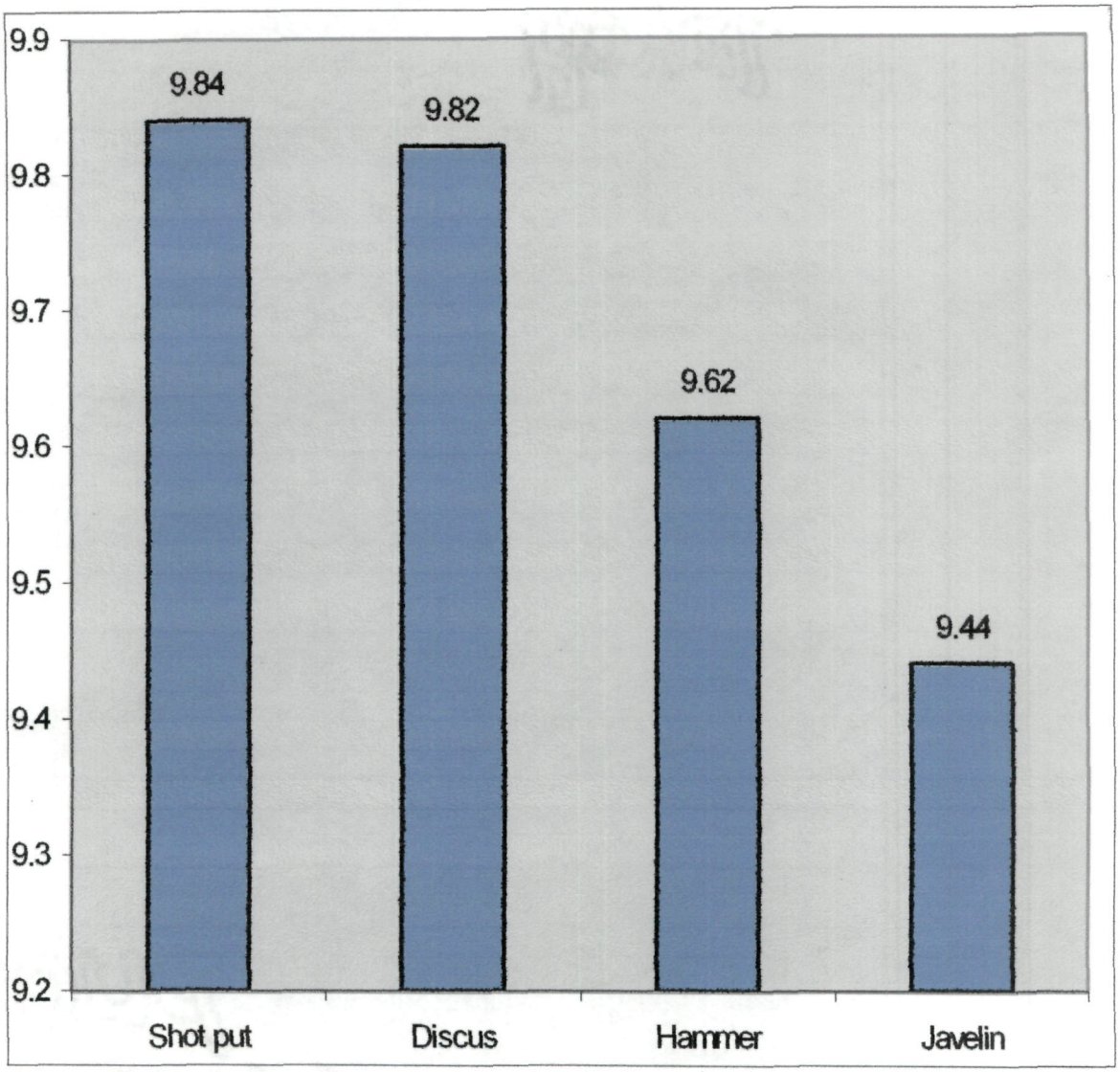


Figure-26; The mean Femur biepicondylar (in cm.) of Throwers (Shot putter, Discus thrower, Javelin thrower and Hammer throwers)

Table-149

Endomorphy

source of variation	d.f.	Ss	mss	F-value
Treatment	r-1=3	19.8	6.6	
Error	N-r=96	85.36	0.889167	7.42268

Significance 0.05 level
Tab F (3, 96) =2.70

Since calculated F value is greater than tabulated F value, the hypothesis is accepted and we conclude that significant difference is existing in the mean endomorphy of Shot put, Discus, Javelin and Hammer throwers. To further find out which group is having greater endomorphy, pair wise mean analysis is done through LSD test.

Table-150

Treatment means arranged in order of magnitude

Throwing groups				Mean difference	CD at 5% level
Shot put	Hammer	Discus	Javelin		
4.49	4.16			0.33	
4.49			3.28	1.21	
4.49		4.08		0.41	0.106
	4.16	4.08		0.08	
		4.08	3.28	0.8	
	4.16		3.28	0.88	

*Significant at 5% level

Comparing the pair wise mean difference with critical difference we are able to conclude that mean endomorphy of Shot putter is significantly greater than mean endomorphy of Hammer, Discus and Javelin throwers. Further mean endomorphy of Hammer thrower is also significantly greater than mean endomorphy of Discus and Javelin throwers and mean endomorphy of Javelin thrower is significantly the least from all the three groups.

ENDOMORPHY

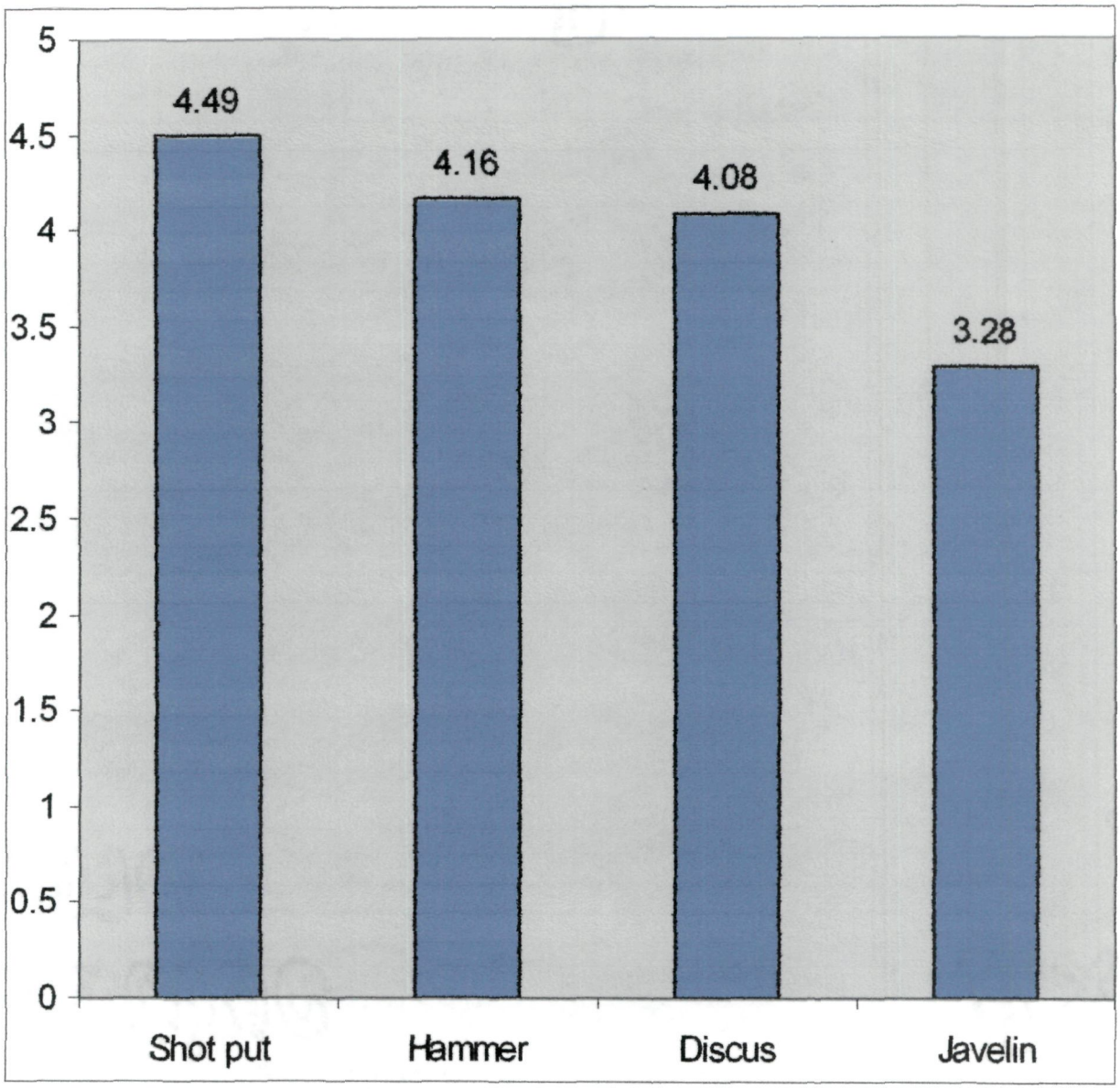


Figure-27; The mean Endomorphy rating of Throwers (Shot putter, Discus thrower, Javelin thrower and Hammer throwers).

Table-151

Mesomorphy

Source of variation	d.f.	ss	mss	F-value
Treatment	r-1=3	61.2	20.4	
Error	N-r=96	186.49	1.942604	10.50137

Significance 0.05 level

Tab F (3, 96) =2.70

Since calculated F value is greater than tabulated F value, the hypothesis is accepted and we conclude that significant difference is existing in the mean mesomorphy of Shot put, Discus, Javelin and Hammer throwers. To further find out which group is having greater mean mesomorphy, pair wise means analysis is done through LSD test.

Table-152

Treatment means arranged in order of magnitude

Throwing groups				Mean difference	CD at 5% level
Shot put	Discus	Javelin	Hammer		
2.42	1.61			0.81	
2.42		0.95		1.47	
2.42			0.32	2.1	0.1561
	1.61	0.95		0.66	
	1.61		0.32	1.29	
		0.95	0.32	0.63	

*Significant at 5% level

Comparing the pair wise mean difference with critical difference we are able to conclude that mean mesomorphy of shot putter is significantly greater than mean mesomorphy of Discus, Javelin and Hammer throwers. Further mean of Discus is also significantly greater than mean mesomorphy of Javelin and Hammer throwers and mean mesomorphy of Hammer thrower is significantly the least from all the three groups.

MESOMORPHY

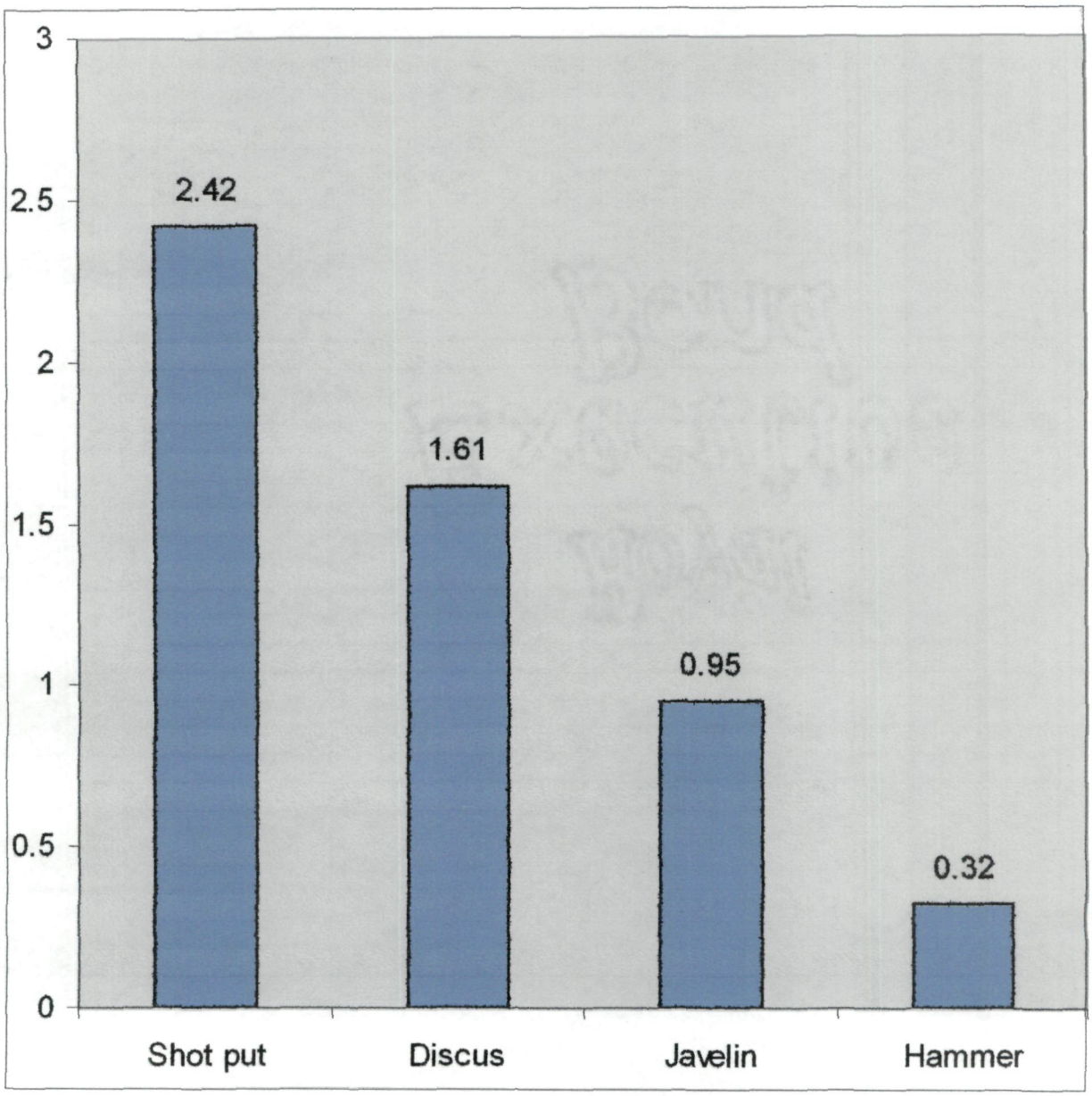


Figure-28; The mean Mesomorphy rating of Throwers (Shot putter, Discus thrower, Javelin thrower and Hammer throwers).

Table-153

Ectomorphy

source of variation	D.f.	s.s.	m.s.s	f-value
Treatment	r-1=3	98.28	32.76	
Error	N-r=96	72.56	0.755833	43.34289

Significance 0.05 level

Tab F (3, 96) =2.70

Since calculated F value is greater than tabulated F value, the hypothesis is accepted and we conclude that significant difference is existing in the mean ectomorphy of Shot put, Discus, Javelin and Hammer throwers. To further find out which group is having greater mean ectomorphy, pair wise means analysis is done through LSD test.

Table-154

Treatment means arranged in order of magnitude

Throwing groups				**Mean difference**	**CD at 5% level**
Javelin	Discus	Hammer	Shot put		
	40.65		38.62	2.03	
41.29			38.62	2.67	0.1
		39.95	38.62	1.33	
41.29	40.65			0.64	
	40.65	39.65		1	
41.29		39.95		1.34	

*Significant at 5% level

Comparing the pair wise mean difference with critical difference we are able to conclude that mean ectomorphy of Javelin throwers is significantly greater than mean ectomorphy of Discus and Hammer throwers, Shot putter. Further mean of Discus is also significantly greater than mean ectomorphy of Hammer and Shot putter and mean ectomorphy of Shot putters is significantly the least from all the three groups.

ECTOMORPHY

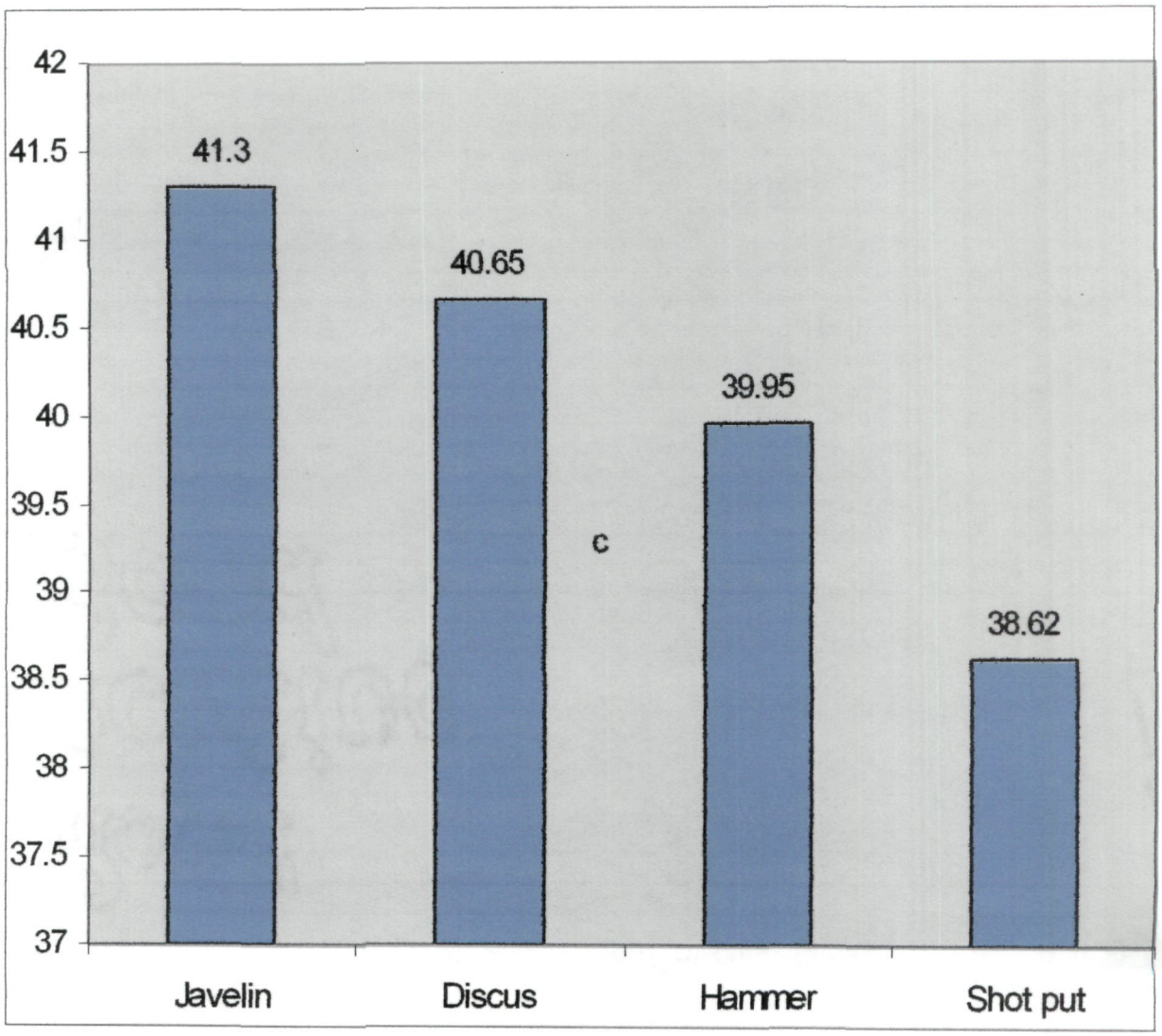


Figure-29; The mean Ectomorphy rating of Throwers (Shot putter, Discus thrower, Javelin thrower and Hammer throwers).

Table-155

Sitting height-Stature index

source of variation	d.f.	ss	mss	F-Value
Treatment	r-1=3	0.163091	0.054364	
Error	N-r=96	3.76416	0.03921	1.386475

Significant at .05 levels

Tab.F.05 (3, 96) =2.70

Since calculated F value is lesser than tabulated F value, we are able to conclude that there is no significant difference in the mean Sitting height –Stature index of Hammer, Shot put, Discuss and Javelin throwers.

SITTING HEIGHT-STATURE INDEX

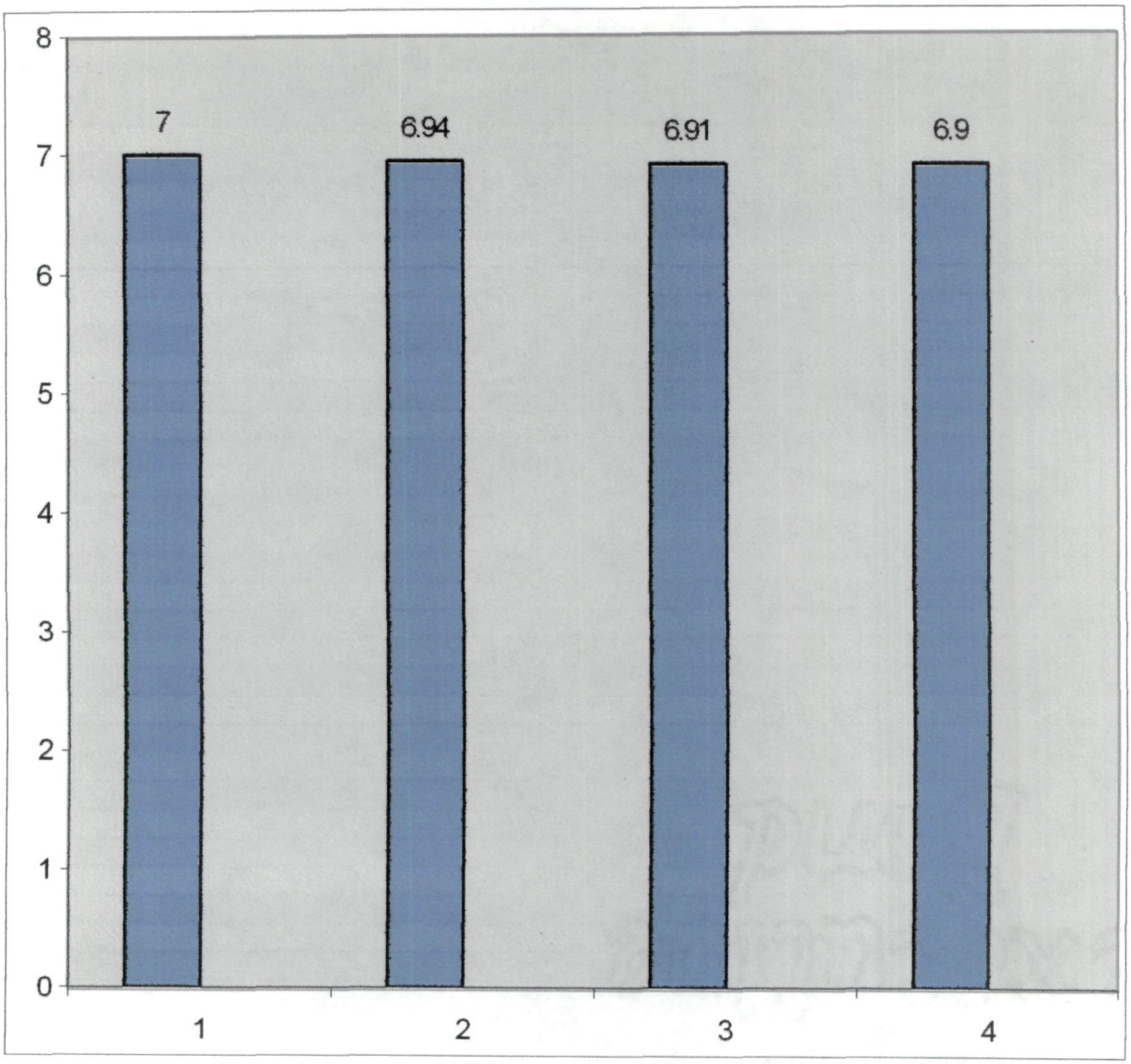


Figure-30; The mean Sitting height-Stature index (in cm.) of Throwers (Shot Putter, Discus thrower, Javelin thrower and Hammer throwers).

Table-156

Ponderal index

source of variation	d.f.	ss	mss	F-Value
Treatment	r-1=3	94.69117	31.56372	
Error	N-r=96	178.3104	1.8574	16.9935

Significance 0.05 level

Tab F (3, 96) =2.70

Since calculated F value is greater than tabulated F value, the hypothesis is accepted and we conclude that significant difference is existing in the mean ponderal index of Shot put, Discus, Javelin and Hammer throwers. To further find out which group is having greater mean Ponderal index, pair wise mean analysis is done through LSD test.

Table-157

Treatment means arranged in order of magnitude

Throwing groups				Mean difference	CD at 5% level
Javelin	Discus	Hammer	Shot put		
41.22	40.65			0.57	
41.22		39.91		1.31	0.15
41.22			38.62	2.6	
	40.65	39.91		0.74	
		39.91	38.62	1.29	
	40.65		38.62	2.03	

*Significant at 5% level

Comparing the pair wise mean difference with critical difference we are able to conclude that mean ponderal index of Javelin throwers is significantly greater than mean ponderal index of Discus, Hammer thrower and shot putter. Further mean ponderal index of Discus thrower is also significantly greater than mean ponderal index of Hammer throwers and Shot putter and mean ponderal index of Shot putter thrower is significantly the least from all the three groups.

PONDERAL INDEX

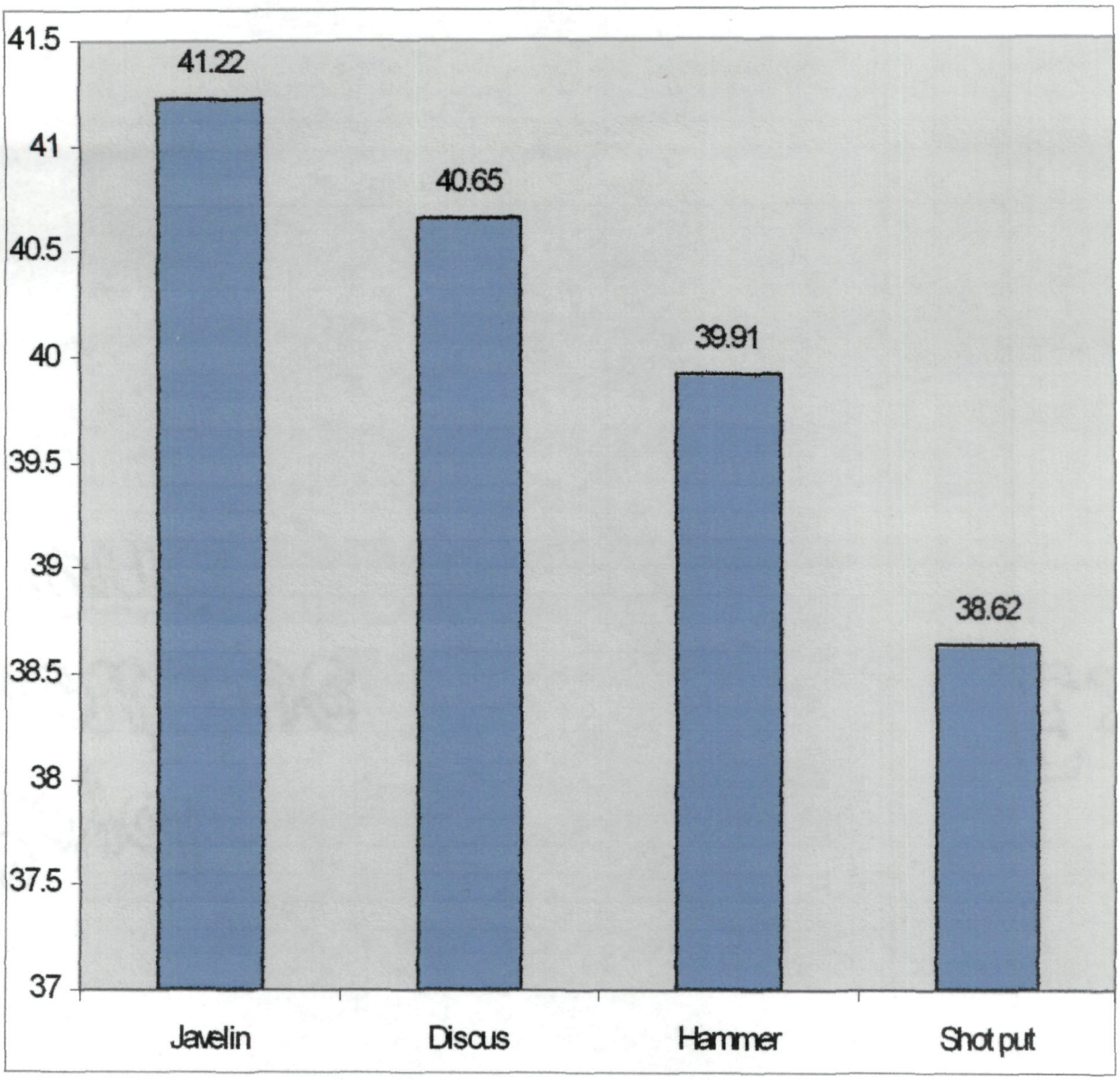


Figure-31; The mean Ponderal index (in cm.) of Throwers (Shot putter, Discus thrower, Javelin thrower and Hammer throwers).

Table-158

Thigh length –lower leg length index

source of variation	d.f.	ss	mss	F-Value
Treatment	r-1=3	35348.8	11782.93	
Error	N-r=96	970266.3	10106.94	1.165826

Significant at .05 levels

Tab.F.05 (3, 96) =2.70

Since calculated F value is lesser than tabulated F value, we are able to conclude that there is no significant difference in the mean thigh length – lower leg length index of Hammer, Shot put, Discus and Javelin throwers.

THIGH LENGTH-LOWER LEG LENGTH INDEX

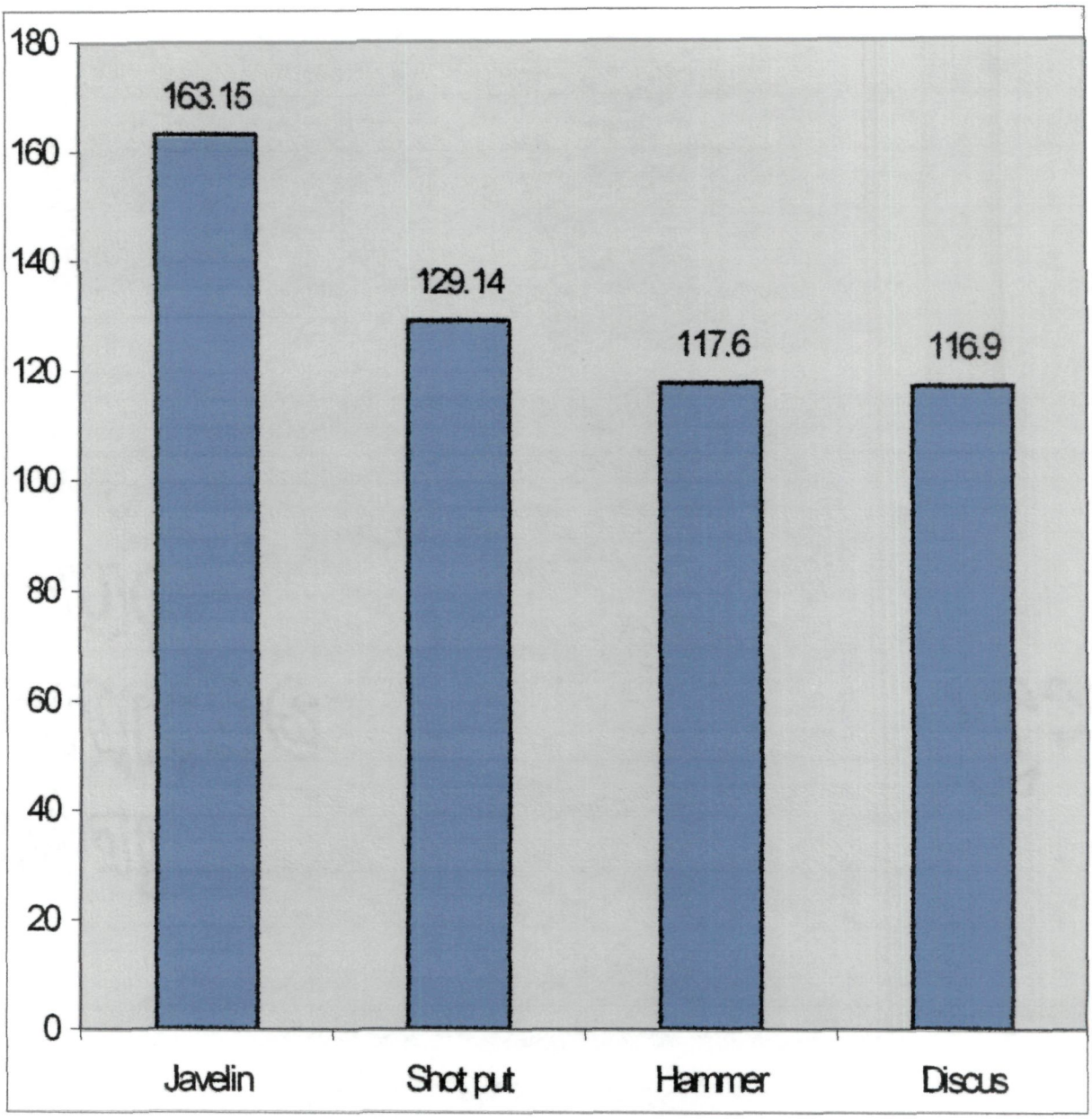


Figure-32; The mean Thigh length-Lower leg length index (in cm.) of Throwers (Shot Putter, Discus thrower, Javelin thrower and Hammer throwers).

Table-159

Upper Arm Length-Lower Arm Length Index

Source of variation	d.f.	ss	mss	f-value
Treatment	r-1=3	8701.801	2900.6	
Error	N-1=96	6522.424	67.9419	42.69235

Significance 0.05 level

Tab F (3, 96) =2.70

Since calculated F value is greater than tabulated F value, the hypothesis is accepted and we conclude that significant difference is existing in the mean upper arm length –lower arm length of Shot put, Discus, Javelin and Hammer throwers. To further find out which group is having greater mean upper arm length –lower arm length, pair wise mean analysis is done through LSD test.

Table-160

Treatment means arranged in order of magnitude

Throwing groups				Mean difference	CD at 5% level
Shot put	Javelin	Hammer	Discus		
130	123.09			6.91	
130			107.18	22.82	0.923
130		110.13		19.87	
	123.09	110.13		12.96	
		110.13	107.18	2.95	
	123.09		107.18	15.91	

*Significant at 5% level

Comparing the pair wise mean difference with critical difference we are able to conclude that mean upper arm length –lower arm length of Shot putter is significantly greater than mean upper arm length –lower arm length of Javelin, Hammer and Discus throwers. Further mean upper arm length –lower arm length of Javelin throwers is also significantly greater than mean upper arm length –lower arm length of Hammer and Discus and mean upper arm length –lower arm length of Discus thrower is significantly the least from all the three groups.

UPPER ARM LENGTH-LOWER ARM LENGTH INDEX

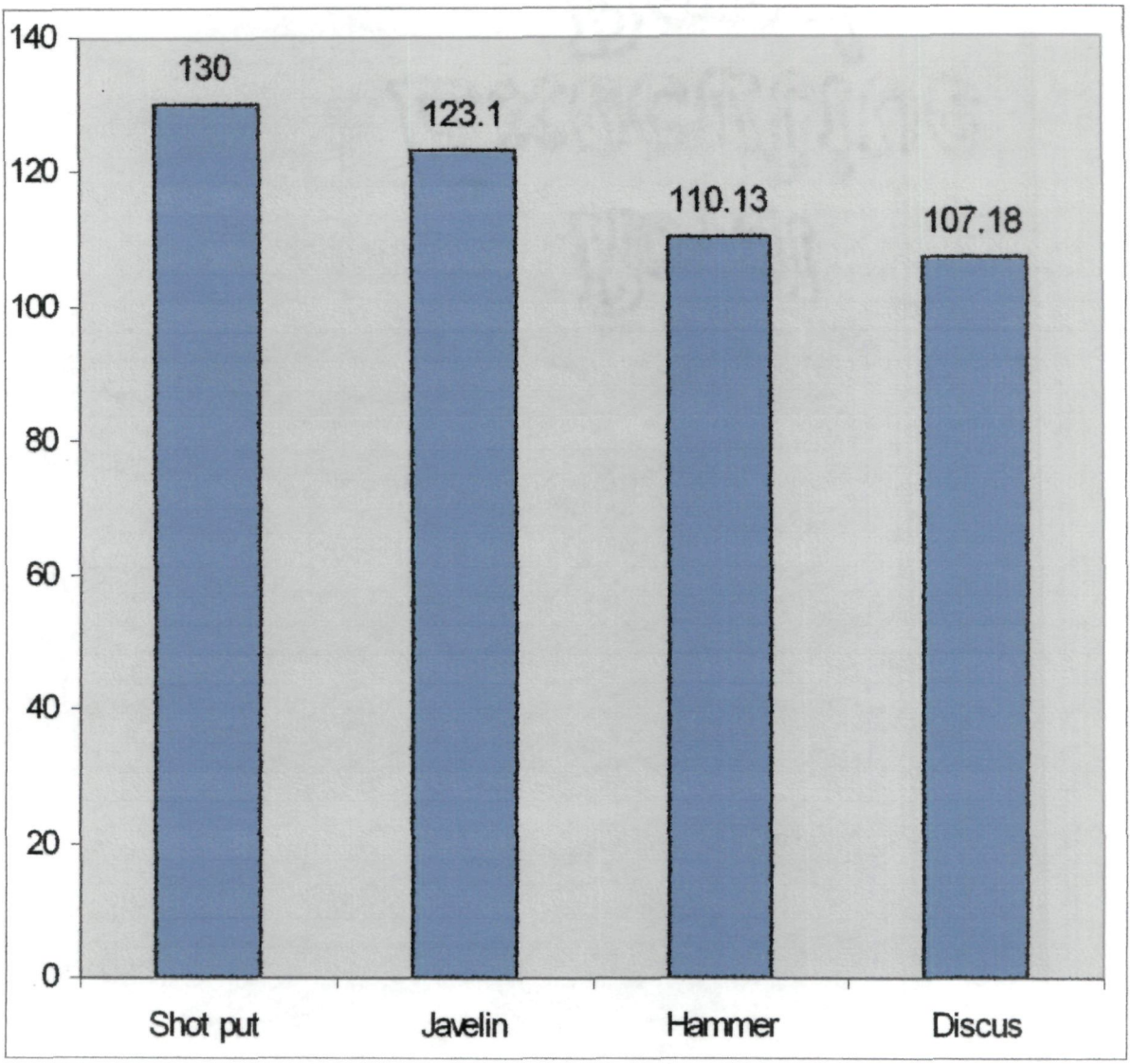


Figure-33; - The mean Upper arm length-Lower arm length index (in cm.) Throwers (Shot putter, Discus thrower, Javelin thrower, Hammer throwers).

Table-161

Hip breadth-Stature index

source of variation	d.f.	ss	mss	F-value
Treatment	r-1=3	130.4026	43.46753	
Error	N-r=96	240.2188	2.502279	17.37118

Significance 0.05 level

Tab F (3, 96) =2.70

Since calculated F value is greater than tabulated F value, the hypothesis is accepted and we conclude that significant difference is existing in the mean hip breadth-stature index of Shot put, Discus, Javelin and Hammer throwers. To further find out which group is having greater mean hip breadth-stature index, pair wise mean analysis is done through LSD test.

Table-162

Treatment means arranged in order of magnitude

Throwing groups				Mean difference	CD at 5% level
Shot put	Discus	Javelin	Hammer		
20.5	18.68			1.82	
20.5			17.7	2.8	0.18
20.5		17.72		2.78	
	18.68		17.7	0.98	
	18.68	17.72		0.96	
		17.72	17.7	0.02	

*Significant at 5% level

Comparing the pair wise mean difference with critical difference we are able to conclude that mean hip breadth-Stature index of Shot putter is significantly greater than mean hip breadth-Stature index of Discus, Javelin and Hammer throwers. Further mean hip breadth-Stature index of Discus is also significantly greater than mean hip breadth-Stature index of Javelin and Hammer throwers, and mean hip breadth-Stature index of Hammer thrower is significantly the least from all the three groups.

HIP BREADTH-STATURE INDEX

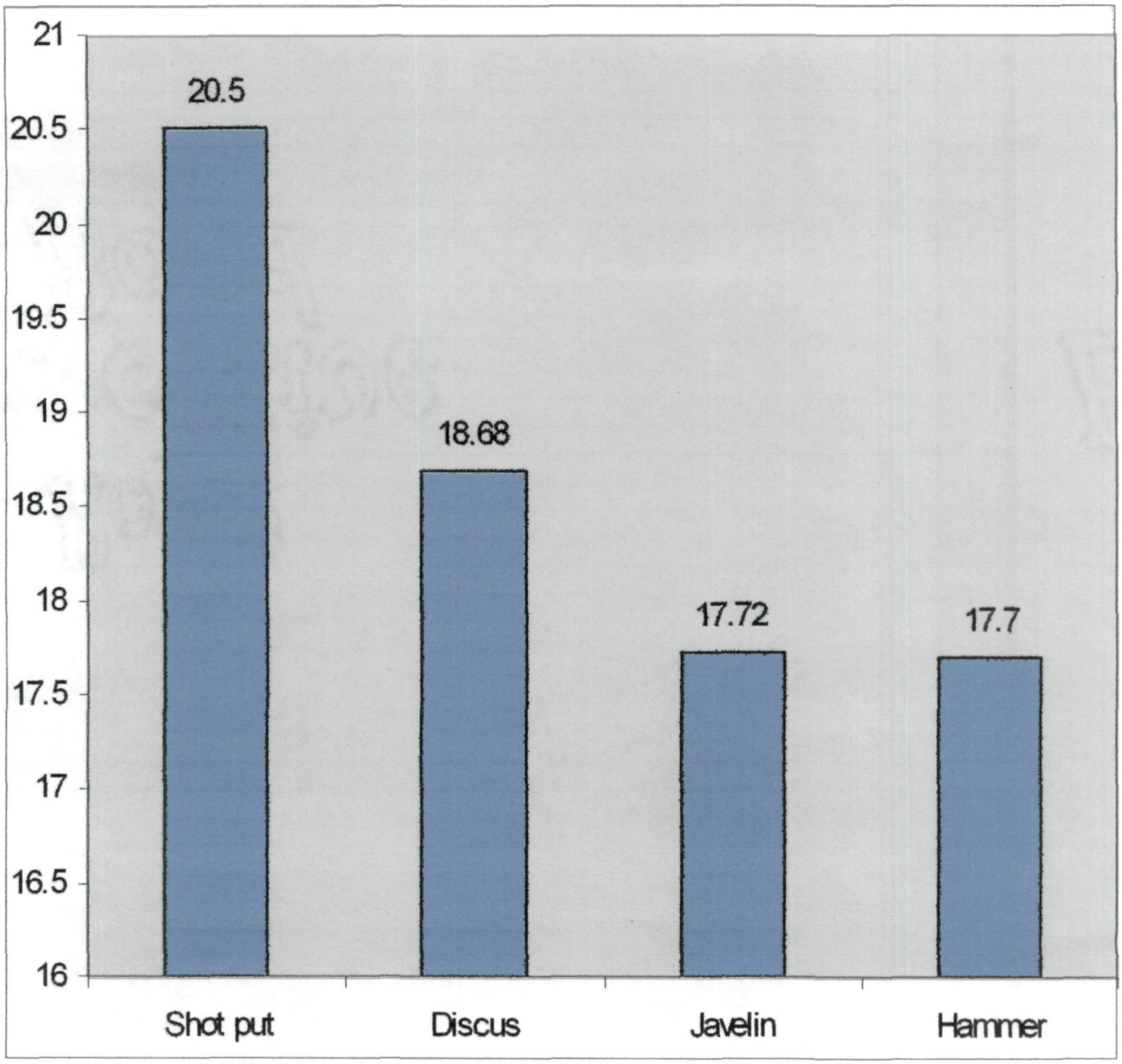


Figure-34; The mean Hip breadth-Stature index (in cm.) of Throwers (Shot putter, Discus thrower, Javelin thrower and Hammer throwers).

Table-163

Shoulder breadth-Stature Index

source of variation	d.f.	ss	mss	F-Value
Treatment	r-1=3	34.64613	11.54871	
Error	N-r=96	202.8982	2.113523	5.464199

Significance 0.05 level

Tab F (3, 96) =2.70

Since calculated F value is greater than tabulated F value, the hypothesis is accepted and we conclude that significant difference is existing in the mean shoulder breadth-stature Index of Shot put, Discus, Javelin and Hammer throwers. To further find out which group is having greater mean shoulder breadth-stature index, pair wise means analysis is done through LSD test.

Table-164

Treatment means arranged in order of magnitude

Throwing groups				Mean difference	CD at 5% level
Hammer	Javelin	Shot put	Discus		
22.94	22.89			0.05	
		22.86	21.53	1.33	0.163
22.94		22.86		0.08	
22.94			21.53	1.41	
	22.89	22.86		0.03	
	22.89		21.53	1.36	

*Significant at 5% level

Comparing the pair wise mean difference with critical difference we are able to conclude that mean shoulder breadth-stature index of Hammer thrower is significantly greater than mean shoulder breadth-stature index of Javelin, Shot put and Discus throwers. Further mean shoulder breadth-stature index of Javelin is also significantly greater than mean shoulder breadth-stature index of Shot put and Discus throwers. And mean shoulder breadth-stature index of Discus thrower is significantly the least from all the three groups.

SHULDER BREADTH-STATURE INDEX

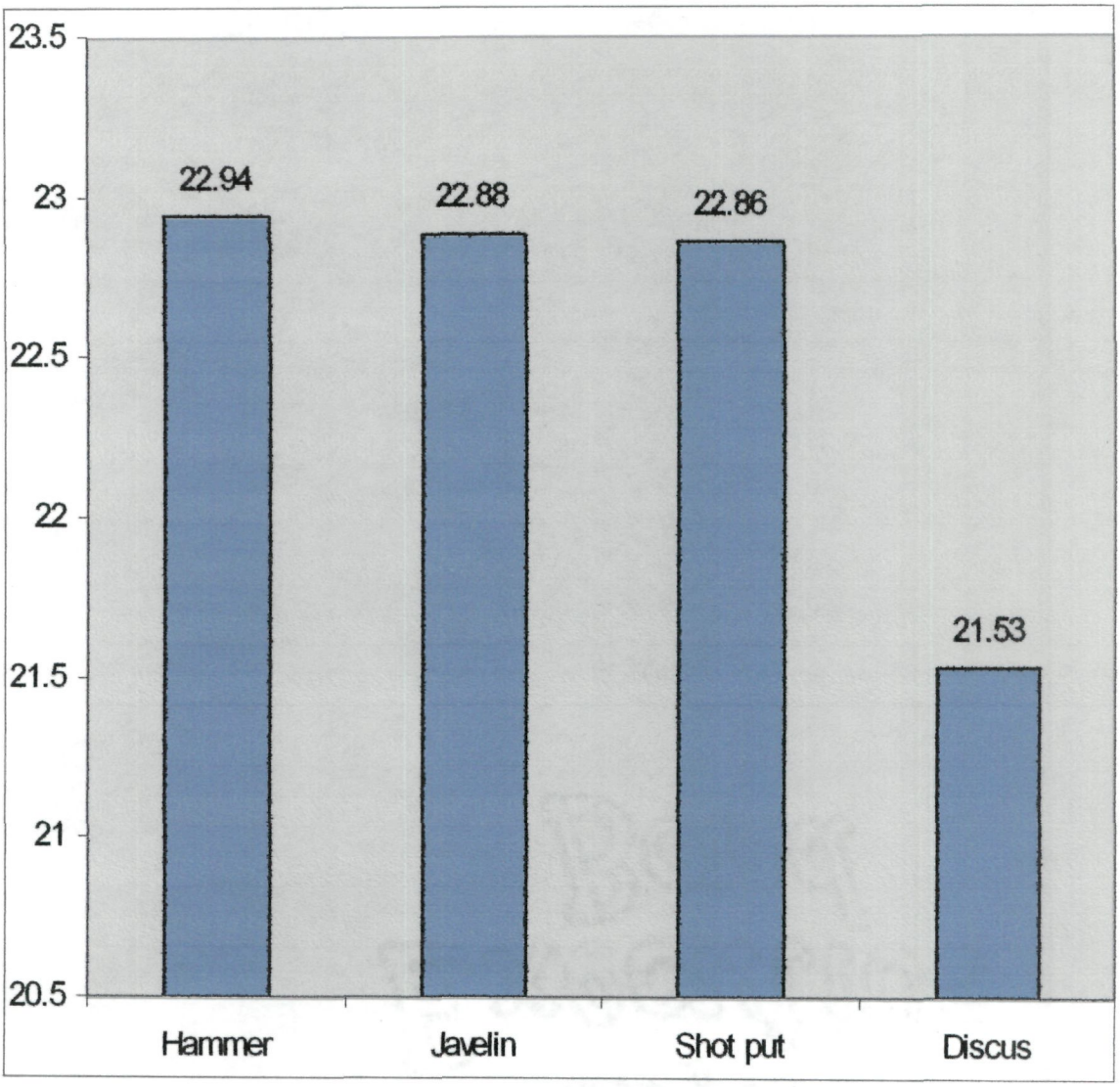


Figure –35; The mean shoulder breadth –stature index (in cm.) throwers (shot putter , discus thrower ,javelin thrower, and hammer throwers).

Table-165

Fat Percentage

source of variation	d.f.	ss	mss	F-Value
Treatment	r-1=3	355.8	118.6	8.098
Error	N-r=96	1405.93	1405.93	

Significance 0.05level

Tab F (3,96)=2.70

Since calculated F value is greater than tabulated F value, the hypothesis is accepted and we conclude that significant difference is existing in the mean fat percentage of Shot put, Discus, Javelin and Hammer throwers. To further find out which group is having greater mean Body composition, pair wise means analysis is done through LSD test.

Table -166

Treatment means arranged in order of magnitude

Throwing groups				Mean difference	CD at 5% level
Shot put	Hammer	Discus	Javelin		
17.3	16.22			0.78	1.79
		15.11	12.23	2.88	
17.3		15.11		2.19	
17.3			12.23	5.07	
	16.22	15.11		1.11	
	16.22		12.23	3.99	

Significant at 5% level

Comparing the pair wise mean difference with critical difference we are able to conclude that mean fat percentage of shot putter is significantly greater than mean fat percentage of Hammer, Discus and Javelin throwers. Further mean fat percentage of Hammer throwers is also significantly greater than mean fat percentage of Discus thrower and Javelin thrower and mean fat percentage of Javelin thrower is significantly the least from all the three group.

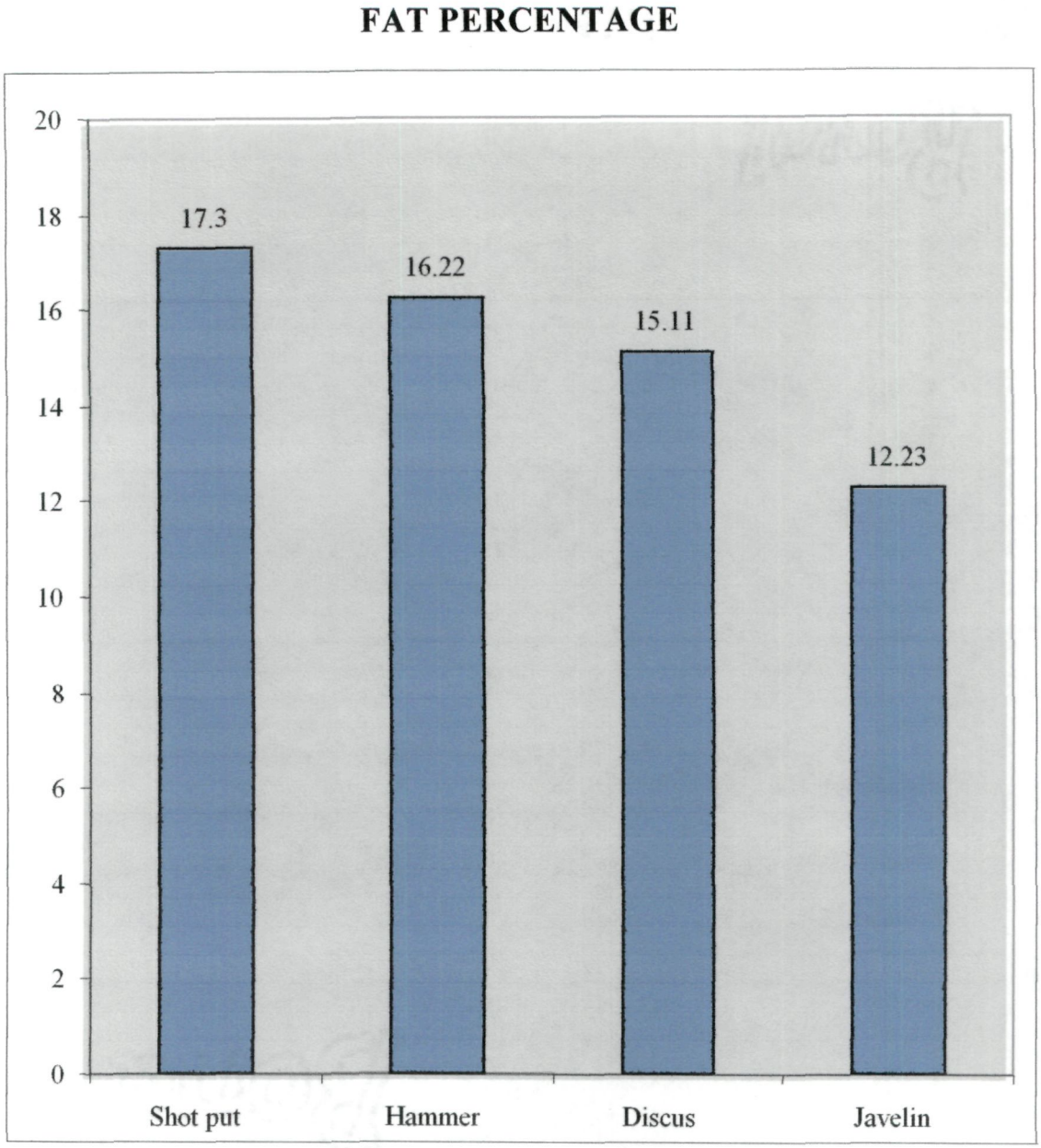


Figure-36; The mean Fat Percentage of Throwers (Shot putter, Discus thrower, Javelin thrower and Hammer throwers).

Table-167

Foot length

Source of variation	d.f.	ss	mss	F- value
Tretment	r-1=3	4.16	1.386667	1.667335
Error	N-r=96	79.84	0.831667	

Significant at .05 levels

Tab.F.05 (3, 96) =2.70

Since calculated F value is lesser than tabulated F value, we are able to conclude that there is no significant difference in the mean Foot length of Hammer, Shot put, Discus and Javelin throwers.

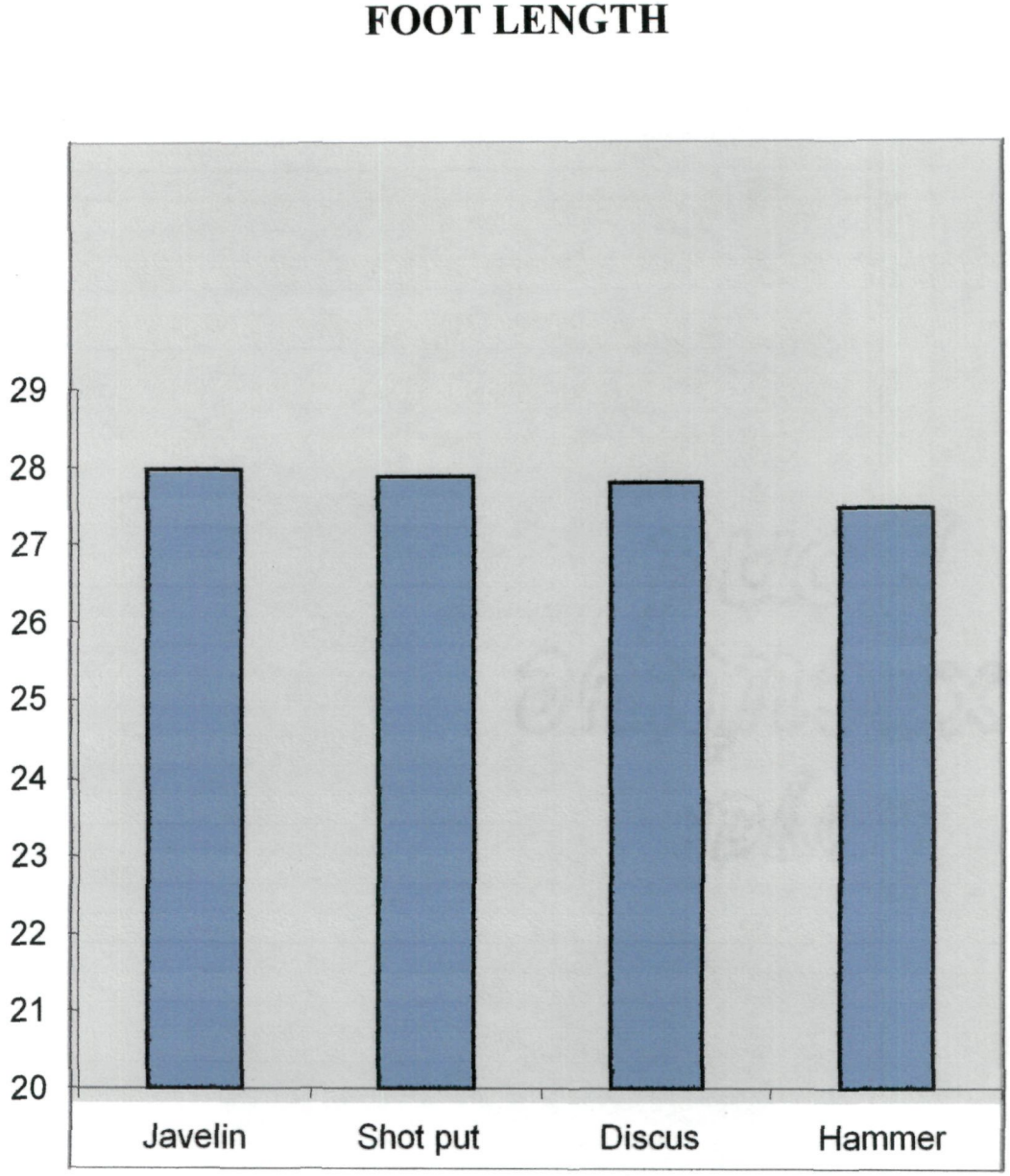


Figure-37; The mean Foot Length in cm. of Throwers (Shot putter, Discus thrower, Javelin thrower and Hammer throwers).

DISCUSSION AND FINDING

SHOT PUT

A positive correlation ship was observed between the performance of Shot putter and their height (0.31), weight (0.72), sitting height (0.09), chest girth & depth (0.45), humerus & femurs biepicondylar (0.75), wrist & ankle breadth (0.66) hip & shoulder breadth (0.12), upper arm length (0.57), lower arm length (0.26), total arm length (0.76), upper leg length (0.49), lower leg length (0.37), total leg length (0.08), muscles girths (0.87), skin folds (0.55), total age & total training age (0.38).

HEIGHT & WEIGHT

Height (0.31) and weight (0.72) of Shot putters are having positive correlation with their performance. Height is a prominent factor in putting the shot to maximum distance. Greater height provides higher point of projection, which increase the projectery path of the throw. Greater height of release with greater segmental length increase the distance course of force application while putting the shot. Thus greater height enhances the chances of good performance.

Greater weight also signifies greater muscular mass, thus greater strength; It also provides greater resistance to counter opposite reactionary force of shot (Newton's IIIrd low of motion). Thus greater weight enhances the chance of good performance. Telka et.al. (1951), Pere et.al. (1954), Sidhu et al. (1975) and M.S.Chauhan (2003) also observed shot putters' performance to be positively correlated with their height & weight.

SITTING HEIGHT

We observed Shot putters' Sitting height to be positively correlated (0.09) with their performance. Greater Sitting height provides higher point of projection, which increase the projectery path of the throwing distance, Greater Sitting height with greater segmental length increase the distance course of force application while putting the Shot. Thus greater sitting height enhances the chances of good performance. Pere et.al. (1954) and M.S.Chauhan (2003) also observed shot putters' performance to be positively correlated with their Sitting height.

CHEST GIRTH & DEPTH

Chest girth & depth of Shot putters are positively correlated (0.45) with their performance in our study. Greater chest girths & depth signifies greater bone area and muscular mass, which gives greater stability and muscular strength, this enhances the chances of good performance. Telka et.al (1951) and M.S.Chauhan (2003) also observed shot putters' performance to be positively correlated with their Chest girth & Depth.

HUMERUS & FEMUR BIEPICONDYLAR BREADTH

We observed Shot putters' humerus & femur biepicondylar breadth to be positively correlated (0.75) with their performance. Greater Humerus & femur biepicondylar width provides greater stability and base for muscular attachment, this helps in greater application of muscular force, and thus chances of good performance are enhanced. The constant stress of weight bearing during their course of training regimen is also responsible for broadening their knees and elbows as pointed out by H.S.Sodhi (1991) who also observed Shot putters' performance to be positively correlated with their humerus &femur biepicondyle breadths.

HIP & SHOULDER BREADTH

Hip & shoulder breadths of Shot putters' are positively correlated (0.12) with their performance in our study. Greater hip & shoulder breadth signifies greater bone surface and muscular mass. Which gives greater stability and power. Greater stability gives more resistance to counteract opposite reactionary force of shot (Newton's IIIrd low of motion). Greater muscular power helps in putting the shot to maximum distance. Telkaet.al. (1951), cureton (1951), pereet.al. (1954)andM.S.Chauhan (2003) also observed shot putters' performance to be positively correlated with their hip & shoulder breadth.

TOTAL ARM LENGTH

We observed Shot putters' total arm length to be positively correlated (0.76) with their performance. Total arm length includes upper arm, lower arm and hand length. Total arm length provides greater segmental length, which increase the height of release, Thus the projectery path of the throwing distance is enhanced. Greater segmental lengths also increase the distance course of force application, which helps in putting the Shot to more distance. Pere et.al. (1954) and M.S. Chauhan (2003) also observed Shot putters' performance to be positively correlated with their total arm length.

TOTAL LEG LENGTH

Total leg length of Shot putters' is having positive correlation (0.08) with their performance in our study. Greater leg length provides efficient glide and greater thrust while turning and also helps in quicker and uninterrupted transition of force to upper body, which helps in maximum

application of power to shot. M.S.Chauhan (2003) also observed Shot putters' performance to be positively correlated with their total leg length.

MUSCLES GIRTH

We observed sum of four muscle girths of Shot putters' to be positively correlated (0.87) with their performance. Greater Muscular girth signifies greater cross sectional area of muscle, As muscular force is directly proportional to cross sectional area of muscle, Thus greater cross sectional area provides greater application of force, which enhances the putting distance. M.S.Chauhan (2003) also observed throwers' performance to be positively correlated with their muscle girths.

SKIN FOLD

Skin fold thikness of Shot putters is positively correlated (0.55) with his performance in our study. The sum of five skin fold measurement is greater in high performers. This gives them extra weight, which gives them higher resistance to counter opposite reactionary force of shot (Newton's IIIrd low of motion). Mokha R & Sidhu (1988) and M.S.Chauhan (2003) also observed Shot putters' performance to be positively correlated with their skin fold thickness.

TOTAL AGE & TRAINING AGE.

We observed total age & training age of Shot putters to be positively correlated (0.38) with their performance. Shot putter had to follow an intensive resistance-training program. Which requires full mineral as well as length and breadth wise maturation of bones and optimum development of muscles. As Shot putter need maximum

muscular strength for which they had to develop optimum muscular mass, which requires a long term weight training program Therefore there training age and total training period for developing optimal performance is greater then other athletes. Also greater total age & training age provides more confidence, that helps in winning the competition. Hirata (1966)) and M.S.Chauhan (2003) also observed Shot putters' performance to be positively correlated with their total age & training age.

WRIST & ANKLE

Wrist & Ankle breadths of Shot putters are positively correlated (0.66), with their performance in our study. Greater wrist & ankle breadth provides wider bone surface for muscular attachment. Which gives greater stability and powerful muscular movement during the release of shot, which enhances the chances of good performance.

FOOT LENGTH

Foot length of Shot putters is negatively correlated (-0.018), with their performance in our study. Lesser foot length may provides powerful ankle thrust, which shall enhances the chances of good performance.

SOMATOTYPE

We observed Shot putters to have greater fat % which makes them more endomorphic (0.43) than mesomorphic (-0.22). The ectomorphy is having a negative (-0.48) correlation with shot putters performance. Which is well understood by the mechanical requirement of the event. Westlake (1967) observed Shot putters to differ from other groups of athletes of his study. He found them to be more heavier greater

endomorphic and mesomorphic. High endomorphy and mesomorphy are thus assets to throwing.

DISCUS THROW

A positive correlation ship was observed between the performance of Discus throwers and their weight (0.51), sitting height (0.45), humerus & femurs Biepicondylar (0.74), lower arm length (0.04), total arm length (0.1), total leg length (0.05), skin folds (0.08), total age & total training age (0.19)

A negative correlation ship was observed between the performance of Discus throwers and their height (-0.13), chest girth & depth (-0.33), wrist ankle breadth (-0.29) hip & shoulder breadth (-0.14), upper arm length (-0.22), upper leg length (-0.38), lower leg length (-0.32) and sum of four muscles girths (-0.33).

HEIGHT

Since a minor negative (-0.13) correlation is observed between height and performance. Which means that total height is slightly negative factor in Discus throw performance. It may be advantageous by providing them lower center of gravity. This gives more stability and speed in turning movement. That helps in creating more centrifugal force. Thus a powerful release of Discus is possible. However our finding are slightly contradictory to the finding of Telka et.al. (1951), Pere et.al. (1954), M.S.Chauhan (2003) who observed height of discus throwers to be slight, positively correlated with their performance.

WEIGHT

We observed weight of Discus throwers to be positively correlated (0.51) with their performance. Greater weight signifies greater muscular mass, thus greater strength. It also provides greater momentum during turning action, Which increase the throwing distance, Thus greater weight enhances the chances of good performance.

Sidhu et.al.(1975) and M.S.Chauhan (2003) also observed weight of discus throwers to have slight positive correlation with their performance.

SITTING HEIGHT

Since height is having a negative correlation and Sitting height of Discus throwers is having positive correlation (0.45), with their performance in our study . This means that leg length of Discus thrower is not much, which gives them more stability (lower center of gravity) along with speed during turning movement, allowing them to generate more centrifugal force. Which results in a powerful release of the Discus. Pere et.al.(1954)and M.S.Chauhan (2003) also observed sitting height of discus throwers to have positive correlation with their performance.

CHEST GIRTH & DEPTH

Negative correlation (-0.33) is observed in our study between chest girth & depth and performance of Discus throwers. Lean chest girth & depth may provide more space for mobility and speed generation, which increases the centrifugal force to a greater advantage for a powerful release of the Discus. However our finding are slightly contradictory to the finding of Telka et.al.(1951)and M.S.Chauhan (2003) who observed

chest depth & girth of throwers to have slight positive correlation with their performance.

HUMERUS & FEMUR BIEPICONDYLE BREADTH

We observed humerus & femurs biepicondylar breadths of Discus throwers to be positively correlated (0.74) with their performance. Greater humerus & femur Biepicondylar breadth provides greater stability and base for muscular attachment, This helps in greater application of force, which increases throwing distance. The constant stress of weight bearing during their course of training regimen is also responsible for broadening their knees and elbows as pointed out by H.S. Sodhi (1991) who also observed Discus throwers' performance to be positively correlated with their humerus & femur biepicondylar widths.

HIP & SHOULDER BREADTH

Hip & shoulder breadths of Discus throwers are negatively correlated (-0.14) with their performance in our study. This means that Hip & Shoulder breadths of discus throwers are not much. However our finding are slightly contradictory to the finding of Cureton (1951), Telka et.al.(1951), Pere et.al.(1954), M.S.Chauhan (2003) who observed hip & shoulder breadths of throwers to have slight positive correlation with their performance .

TOTAL ARM LENGTH

We observed total arm length of Discus throwers' to be positively correlated (0.1), with their performance. Total arm length includes upper arm, lower arm and hand length. Except upper arm length, lower arm and hand lengths are positively correlated with performance. Greater hand

length with powerful fingers helps in powerful grip along with greater spin and forceful release of the Discus. Greater lower hand length, along with greater segmental length also increases the radius of force application, and increasing the height of release, thus the projectery path of the throwing distance is enhanced. Pere et.al. (1954) and M.S.Chauhan (2003) also observed total arm length of discus throwers to have positive correlation with their performance.

TOTAL LEG LENGTH

Total leg length of Discus throwers is having positive correlation (0.05) with their performance in our study. Greater leg length provides greater and efficient turning and a powerful thrust, which helps in quicker and uninterrupted transition of force to upper body, this helps in maximum application of power to discus. M.S.Chauhan (2003) also observed Discus throwers' performance to have positive correlation with their total leg length.

MUSCLES GIRTH

We observed muscle girths of four sites are having negative correlation (-0.33) with Discus throwers' performance. Lesser body mass provides more power and good movement co-ordination during throwing the Discus, which enhances the throwing distance. Discus throw does not require maximum strength. It needs explosive strength for speed and power. However our finding are slightly contradictory to the finding of Sidhu et.al. (1975), M.S.Chauhan (2003), who observed muscle girths of throwers to have slight positive correlation with their performance.

SKIN FOLD

Skin fold thickness of Discus throwers is having slightly positively correlation (0.08), with their performance in our study. That shows high performer to have more fat and muscular mass. Which might enhance angular momentum during throwing the Discus. M.S.Chauhan (2003) also observed throwers' skin folds to have positive correlation with their performance.

FOOT LENGTH

Foot length of Discus thrower is negatively correlated (-0.018), with their performance in our study. Lesser Foot length will provide powerful ankle thrust, which may enhance the chances of good performance.

TOTAL AGE & TRAINING AGE

We observed total age & training age of Discus throwers to be positively correlated (0.19) with their performance. Discus thrower had to follow an intensive resistance-training program, which requires full mineral as well as length and breadth wise maturation of bones and optimum development of muscles. As Discus thrower need explosive muscular strength for which they had to develop optimum muscular mass, which requires a long-term weight-training program, therefor there training age and total training period for developing optimal performance is greater then other athletes. Also greater total age & training age provides more confidence, that helps in winning the competition. Hirata (1966) and M.S.Chauhan (2003) also observed total age & training age of Discus throwers to have positive correlation with their performance.

SOMATOTYPE

Our findings indicate Discus thrower's performances to be more positively correlated with their ectomorohy (.37) then their endomorphy (.11). However their performance is having a negative correlation (-. 33) with mesomorphy. Westlake (1967) observed throwers' differ from other groups of athletes of his study. He found them to be more heavier, greater endomorphic and mesomorphic. According to him high endomorphy and mesomorphy are assets to throwing.

JAVELIN THROW

Positive correlation ship were observed between performance of Javelin throwers and their height (0.15), chest girth & depth (0.4), hip & shoulder breadth (0.05), upper leg length (0.23), lower leg length (0.46), total leg length (0.26), muscles girths (0.32), skin folds (0.06), total age & total training age (0.07).

Negative correlation ship were observed between the performance and weight (-0.33), sitting height (-0.08), humerus & femurs biepicondylar breadth (-0.19), wrist ankle breadth (-0.15), upper arm length (-0.29), lower arm length (-0.39), total arm length (-0.03).

HEIGHT & WEIGHT

Height is a prominent factor in throwing the Javelin to maximum distance. Greater height provides greater height of release, higher point of projection, which increase the projectery path of the throw, this increases the throwing distance of Javelin.

Since negative (-0.33) correlation is observed between weight and

performance. Lesser muscular mass with lesser fat provides greater explosive strength with stability and flexibility of throwing movement. Thus lesser weight enhances the chances of good performance. Telka et.al. in (1951)Pere et.al.(1954), Sidhu et.al.(1975) and M.S.Chauhan (2003) observed throwers to have positive correlation between height and their performance .

SITTING HEIGHT

We observed total leg length of Javelin throwers is positively correlated and sitting height of Javelin throwers is having a minor negative correlation (-0.08) with their performance, this means that lesser sitting height provides early transition of power from lower body to throwing implement. This results in fast accumulation of various body forces. Thus greater force application to javelin is possible.

However our finding are slightly contradictory to finding of M.S.Chauhan (2003), who observed performance of Javelin throwers to be slightly positively correlated with their Sitting height.

CHEST GIRTH & DEPTH

Chest girths & depth are positive correlation (0.05), with performance of Javelin throwers in our study. Greater chest girths & depth signifies greater bone area and muscular mass, which gives greater stability and explosive strength, which promotes greater chances of good performance. Telka et.al. (1951) and M.S.Chauhan (2003), also observed Javelin throwers to have positively correlated Chest girth & depth with their performance.

HIP & SHOULDER BREADTH

We observed hip & shoulder breadths of Javelin throwers are positively correlated (0.05), with their performance. Greater hip & shoulder breadth signifies greater bone surface and muscular mass. Which provide greater stability and power. Which very much required for creating of powerful shoulder jerk. Thus helps in throwing the Javelin to maximum distance. Cureton (1951), Telka et.al. (1951), Pere et.al. (1954) and M.S.Chauhan (2003), also observed performance of Javelin thrower to be positively correlated with their hip & shoulder breadth.

TOTAL ARM LENGTH

We observed Javelin throwers' total arm length to have negatively correlated (-0.03) with their performance. Total arm length includes upper arm, lower arm and hand length. Lesser total arm length provides greater arms jerk at the time of release, which helps in throwing the Javelin to more distance. However our finding are slightly contradictory to finding of Cureton (1951),Pere et.al.(1954) and M.S.Chauhan (2003), wwho observed total arm length of throwers to be slightly positively correlated with their performance.

TOTAL LEG LENGTH

Total leg length of Javelin throwers is having positive correlation (0.26), with their performance. Greater total leg length provides efficient impulse and greater thrust during stride and helps in quicker and uninterrupted transition of force to upper body in penultimate strides, which helps in maximum application of power to Javelin. M.S.Chauhan

(2003) also observed performance of throwers to be positively correlated with their total leg length.

FOOT LENGTH

Foot length of Javelin thrower is negatively correlated (-0.018), with their performance in our study. Lesser foot length will provides powerful ankle thrust, which shall enhances the chances of good performance.

MUSCLES GIRTH

Sum of four-muscle girth of Javelin throwers is having positive correlation (0.32), with their performance in our study. Greater muscular girth signifies greater cross sectional area of muscle, muscular force is directly proportional to cross sectional area of muscle, thus greater cross sectional area provides greater application of force, which enhances the throwing distance. M.S.Chauhan (2003), also Observed throwers performance to be positively correlated with their muscular mass.

TOTAL AGE & TRAINING AGE

Minor (0.07) positively correlations are observed between total age & training age and performance of Javelin throwers. They had to follow an intensive resistance-training program. Which requires full mineral as well as length and breadth wise maturation of bones and optimum development of muscles. As Javelin thrower need explosive strength for which they had to develop optimum muscular mass, which requires a long term weight training program, there for there training age and total training period for developing optimal performance is greater then other

athletes. Also greater total age & training age provides more confidence, that helps in winning the competition.

Hirata (1966) and M.S.Chauhan (2003), also observed total age & training age to be positively correlated with performance of throwers.

SOMATOTYPE

The performance of Javelin throwers is more positively correlated with ectomorphy (.25) than mesomorphy (.12) followed by endomorphy (0.06). Westlake (1967) observed throwers' differ from other groups of athletes of his study. He found them to be more heavier greater endomorphic and mesomorphic. High endomorphy and mesomorphy are assets to throwing in his study.

HAMMER THROW

A positive correlation ship is observed between the performance and height (0.26), weight (0.23), sitting height (0.06), chest girth & depth (0.19), humerus & femurs Biepicondyle breadth (0.28), wrist ankle breadth (0.17) hip & shoulder breadth (0.17), upper arm length (0.23), lower arm length (0.06), total arm length (0.83), upper leg length (0.12), lower leg length (0.02), total leg length (0.31), muscles girths (0.09), skin folds (0.22), total age & total training age (0.55).

HEIGHT, SITTING HEIGHT AND WEIGHT

Height (0.26) & sitting height (0.06) and weight (0.23) of Hammer throwers are having positive correlation with their performance. Height & sitting height is a prominent factor in throwing the Hammer to maximum

distance. Greater height provides higher point of release, which increase the projectery path of the Hammer. Greater segmental length increase the distance course of force application while throwing. Thus greater height enhances the chances of good performance. Greater weight also signifies greater muscular mass, thus greater explosive strength, Greater weight also provides greater resistance to counter centrifugal force of Hammer while turning movement, thus greater weight enhances the chances of good performance. Sidhu & Wadhan (1974), Sidhu et al. (1975), H.S. Sodhi (1991), and M.S.Chauhan (2003) also observed Hammer thrower to have positively correlated height, weight & sitting height with their performances.

MUSCLES GIRTH

Muscle girths of Hammer throwers are having positive correlation (0.19) with their performance in our study. Greater muscle girths signifies greater bone area and muscular mass. Which gives greater stability and explosive strength, This result in greater application of power, which increases the throwing, distance. Shidu et.al. (1975) and M.S.Chauhan (2003) also observed muscles girth of throwers to be positively correlated with their performance.

CHEST GIRTH & DEPTH

We observed chest girths & depth of Hammers are positively correlated (0.19) with their performance. Greater chest girths & depth signifies greater bone area and muscular mass. Which gives greater stability and explosive strength, this result in greater application of power, which increases the throwing distance. Telka et.al. in (1951), Pere

et.al.(1954), and M.S.Chauhan (2003), also observed Hammer thrower to have positive correlation between chest girth & depth and their performance.

HUMERUS & FEMUR BIEPICONDYLE BREADTHS

We observed humerus & femurs biepicondyle breadths of Hammer throwers are positively correlated (0.28) with their performance. Greater humerus & femurs biepicondyle widths provides greater stability and base for muscular attachment, this helps in greater application of muscular force, and thus chances of good performance are enhanced. The constant stress of weight bearing during their course of training regimen is also responsible for broadening their knees and elbows as pointed out by H.S.Sodhi (1991) who also observed general throwers' performance to be positively correlated with their humerus &femur biepicondyle widths.

HIP & SHOULDER BREADTH

Hip & shoulder breadths of Hammer throwers are positively correlated (0.17) with their performance in our study. Greater Hip & shoulder breadth signifies greater bone surface and muscular mass. This gives greater stability and power. Greater stability gives more resistance to counteract centrifugal force of Hammer during turning movement Telka et.al. (1951), and M.S.Chauhan (2003) observed hip & shoulder breadths of hammer throwers to be positively correlated with their performance.

TOTAL ARM LENGTH

We observed total arm length of Hammer thrower to be positively correlated (0.83) with their performance. Total arm length includes upper arm, lower arm and hand length. Total arm length provides greater segmental length, which increases the radius of hammer rotation. This results in greater development of centrifugal force. Greater total arm length also increases the height of release. Thus the chances of greater performance are enhanced. Pere et.al. (1954) and M.S.Chauhan (2003), also observed total arm length of throwers to be positively correlated with their performance.

TOTAL LEG LENGTH

Total leg length is having positive correlation (0.31) with performance of Hammer throwers. Greater leg length provides greater thrust while turning movement and helps in quicker and uninterrupted transition of force to upper body, which helps in maximum application of power to Hammer. Eiben (1972) and M.S.Chauhan (2003), also observed performance of throwers to be positively correlated with their total leg length.

TOTAL AGE & TRAINING AGE

Total age & training age are positively correlated (0.55) with performance of Hammer throwers in our study. Hammer thrower had to follow an intensive resistance-training program. Which requires full mineral as well as length and breadth wise maturation of bones and optimum development of muscles. As Hammer thrower need explosive muscular strength for which they had to develop optimum muscular mass,

which requires a long term weight training program, there for there training age and total training period for developing optimal performance is greater then other athletes. Also greater total age & training age provides more confidence, that helps in winning the competition. Hirata (1966) and M.S.Chauhan (2003) also observed performance of throwers to be positively correlated with their total age and training age.

FOOT LENGTH

Foot length of Hammer thrower is positively correlated (0.207) with their performance. Greater foot length provides greater stability at the time of turning movement. It helps in creating great torque at the ankle turst just before the release of the Hammer. Which enhance the chances of good performance.

SOMATOTYPE

In our study the performance of Hammer throwers is having positive correlation with endomorphy (.15), a negative correlation with mesomor- phy (-0.4) and high negative correlation with ectomorphy (-. 3). Greater endomorphy signifies greater muscular mass thus greater strength; it also helps in creating greater centrifugal force. Westlake (1967) observed throwers' differ from other groups of athletes of his study. He found them to be more heavier greater endomorphic and mesomorphic. High endomorphy and mesomorphy are assets to throwing in his study.

The statistical analysis revealed insignificant differences among the following variable of Shot put, Discus, Javelin and Hammer throwers : -

1) **Total age**
2) **Sitting height**
3) **Foot length**
4) **Sitting height –statue index**
5) **Thigh length –lower leg length index**

COMPARATIVE ANALYSIS

WEIGHT

Comparing the pair wise mean difference with critical difference we are able to conclude that mean weight of Shot putter is significantly greater than mean weights of Discus, Hammer and Javelin throwers. Further mean weight of Discus thrower is also significantly greater than mean weights of Hammer and Javelin throwers and mean weight of Javelin thrower is significantly the least from all the three groups.

Shot putter need maximum explosive strength for putting the Shot to greater distance, For this they require greater muscular mass along with greater fat mass for resisting opposite reactionary force of Shot (Newton's IIIrd low motion)

Hammer thrower also need greater weight for counteracting centrifugal force and creating greater momentum while taking turn. Shot putters are using linear application of force to propel the Shot where as Hammer thrower are using centrifugal force. Therefore the requirement of weight for Shot putter is greater than Hammer thrower.

In Discus throw principles of aerodynamics are used. Discus is of lighter weight than Shot put & Hammer. Discus thrower requires greater speed during turning movement to create greater centrifugal force. Therefore the requirement of weight for Discus thrower is lesser than Shot putter and Hammer thrower.

Javelin also moves under the principles of aerodynamics. As the weight of Javelin is only 800 gram therefore the requirement of maximum strength is not there. Javelin throwers need greater power to execute the throw to maximum distance. They need a natural shoulder jerk. Therefore they are the lightest of all the throwers.

HEIGHT

Comparing the pair wise mean difference with critical difference we are able to conclude that mean height of Discus throwers is significantly greater than mean heights of Shot putter, Javelin and Hammer throwers. Further mean height of Shot putter is also significantly greater than mean heights of Javelin and Hammer throwers and mean height of Hammer thrower is significantly the least from all the three groups.

Shot putters are using linear application of force where as Hammer and Discus thrower use centrifugal force to propel their respective implements. Lesser height of hammer and Discus thrower is compensated by getting more stability. Greater stability helps in speedy turning movement resulting in the development of greater centrifugal force. Javelin is the lighter of all the four implements; it moves under the principles of aerodynamics, a powerful natural jerk of shoulder is necessary to execute the throw to maximum distance. Therefore requirement of height is compensated by effective technique and powerful natural shoulder jerk.

CHEST GIRTH & DEPTH

Comparing the pair wise mean difference with critical difference we are able to conclude that mean chest girth & depth of Shot putter is significantly greater than mean chest girth & depth of Hammer, Discus and Javelin throwers. Further mean chest girth & depth of Hammer thrower is also significantly greater than mean chest girth & depth of Discus and Javelin throwers the mean chest girth & depth of Javelin thrower is significantly the least from all the three groups.

Shot putter need explosive strength for putting the shot to greater distance, For this they require greater chest girth & depth along with lesser fat mass for creating more application of force.

Hammer thrower also need greater chest girth & depth for counteracting centrifugal force while taking turn. Shot putters are using linear application of force to propel the Shot, where as Hammer throwers are using centrifugal force. Therefore the requirement of chest girth & depth for Shot putter is greater than Hammer thrower.

In Discus throw principles of aerodynamics are used. Discus thrower requires greater speed during turning movement to create greater centrifugal force. Therefore the requirement of chest girth & depth is lesser for Discus thrower than Shot putter and Hammer thrower.

Javelin also moves under the principles of aerodynamics. Javelin throwers need greater power to execute the throw to maximum distance. They need a natural shoulder jerk. Therefore they are the lightest of all the throwers.

HIP & SHOULDER BREADTH

Comparing the pair wise mean difference with critical difference we are able to conclude that mean Hip breadth of Shot putter is significantly greater than mean Hip breadth of Discus, Javelin, and Hammer throwers. Further mean Hip breadth of Discus thrower is also significantly greater than mean Hip breadth of Javelin and Hammer throwers and mean Hip breadth of Hammer thrower is significantly the least from all the three groups.

Shot putter needs greater hip & shoulder breadth for putting the Shot to maximum distance. Greater hip & shoulder breadth signifies

greater bone surface and muscular mass. Which gives greater stability and power, Greater stability gives more resistance to counteract opposite reactionary force of Shot.

Hammer thrower also need greater weight for counteracting centrifugal force while taking turn. Shot putters are using linear application of force to propel the Shot where as Hammer thrower is using centrifugal force. Therefore the requirement of Hip & Shoulder breadth for Shot putter is greater than Hammer thrower.

In Discus throw principles of aerodynamics are used. Discus throwers are having lesser hip & shoulder breadths in comparison to Shot putters & Hammer throwers. Discus thrower requires greater speed during turning movement to create greater centrifugal force. Therefore the requirement of hip & shoulder breadth for Discus thrower is lesser than Shot putter and Hammer thrower.

Javelin also moves under the principles of aerodynamics. Javelin throwers need greater power to execute the throw to maximum distance. They need a natural shoulder jerk. Therefore their hip and shoulder breadth is least of all the throwers.

TOTAL ARM LENGTH

Comparing the pair wise mean difference with critical difference we are able to conclude that mean total arm length of Javelin throwers is significantly greater than mean total arm length of Discus, Shot put and Hammer throwers. Further mean total arm length of Discus thrower is also significantly greater than mean total arm length of shot putter and Hammer throwers and mean total arm length of Hammer thrower is significantly the least from all the three groups.

The Javelin throwers need greater long arm length for throwing the Javelin to maximum distance. The greater arm length provides greater bone lever and arm jerk during the throwing of the Javelin.

Discus throwers needs longer arm length for taking greater radius during rotation in the circle. Javelin throwers are using linear application of force to throw the Javelin where as Discus throwers are using centrifugal force. Therefore the requirement of greater arm length for javelin throwers is greater than discus throwers.

Shot putters require maximum strength during the putting of Shot. Therefore the requirement of arm length for Shot putter is lesser than javelin throwers and discus thrower.

Hammer throwers also needs maximum strength while giving turn to the Hammer, On each turn they had to pull the Hammer toward their chest. Arm length helps in the development of more power. Which enhances the speed of turns. Therefore the requirement of long arms is lesser for Hammer thrower.

However Dyson (1963) has propounded that while throwing the Discus, the speed of the discus at the moment of release is of prime importance in determining how far it will go, and for given angular velocity dependent on how far the 'lever' throwing the Discus is i.e. the distance of the Discus from the axis of the thrower; hence the desirability of having long and powerful arms.

TOTAL LEG LENGTH

Comparing the pair wise mean difference with critical difference we are able to conclude that mean total leg length of discus throwers is significantly greater than mean total leg length of, Hammer, Javelin

throwers and Shot putter. Further mean total leg length of Hammer thrower is also significantly greater than mean total leg length of Javelin throwers and Shot putter mean and total leg length of Shot putter is significantly the least from all the three groups.

Lesser total leg length means greater upper segmental length. Lesser leg length of Shot putter helps in stability during stance and foots placement with easiness in diameter coverage of the circle. Greater leg length also helps in the development of greater distance course of force application.

Lesser leg length of Javelin thrower helps in taking effective strides. Lesser leg length of Hammer throwers also helps in effective step turning and foot placement, which also increases the course of force application for hammer throwers. Discus thrower had least upper segmental length, which gives them more stability during turning movement and foot placement. This increase the speed of their turning, thus centrifugal force is enhanced which takes the Discus to maximum distance.

SKIN FOLD

Comparing the pair wise mean difference with critical difference we are able to conclude that mean Skin folds of Shot putter is significantly greater than mean Skin folds of Hammer, Discus and Javelin throwers. Further mean Skin folds of Hammer thrower is also significantly greater than mean Skin folds of Discus and Javelin throwers and mean skin folds of Javelin thrower is significantly the least from all the three groups

Shot putter needs greater weight for a good performance. Skin folds measurements are greater in high performers of shot put. This gives them extras weight, which gives them higher resistance to counter opposite reactionary force of shot (Newton's IIIrd low of motion).

Hammer thrower also need greater weight for counteracting centrifugal force while taking turn. Shot putters are using linear application of force to propel the shot where as Hammer throwers are using centrifugal force. Therefore the requirement of weight for Shot putter is greater than Hammer thrower.

In Discus throw principles of aerodynamics are used. Discus thrower requires greater speed during turning movement to create greater centrifugal force. Therefore excess fat mass retard their speed. Thus Discus thrower are having lesser fat % than Shot putter and Hammer thrower.

Javelin also moves under the principles of aerodynamics. Javelin throwers need greater power to execute the throw to maximum distance. They need a natural shoulder jerk with good speed in which excess weight of fat will provide hindrance. Therefore they are having lesser skin folds thickness of all the throwers.

Durnin & Womersly (1974) found that the thrower possessed significantly more fat of all the six measurement parameters than the jumpers and runners. The jumpers and runners did not differ much from each other. With the increases levels of competition a trend of increasing in fat was observed in throwers and a decrease in jumpers and runners.

MUSCLES GIRTHS

Comparing the pair wise mean difference with critical difference we are able to conclude that mean muscles girths of Shot putters is significantly greater than mean muscle girths of Discus, Hammer and Javelin throwers. Further mean muscle girths of Discus thrower is significantly greater than mean muscle girths of Hammer and Javelin throwers and mean muscle girths of Javelin thrower is significantly the least from all the three groups.

Shot putters need maximum explosive strength of all the throwers to propel the shot to maximum distance. They had to apply linear force on a shot of 7.26 kg. Hammer throwers use rotational force to throw the Hammer of 7.26 kg. They also need maximum explosive strength, but lesser than Shot putters. Therefore muscle girths of Hammer throwers are lesser than Shot putters.

Discus throwers need greater speed with power to throw the Discus of 2kg. Therefore the requirement of greater muscular girth for maximum strength is not much for them in comparison to Shot putters and Hammer throwers.

Javelin thrower use natural shoulder jerk to throw the Javelin of 800 gm. They need maximum speed, therefore the requirement of greater muscular mass is least for them among all the throwers.

FEMUR & HUMERUS BIEPICONDYLE WIDTHS

Comparing the pair wise mean difference with critical difference we are able to conclude that mean femur biepicondyle breadths of Shot putter is significantly greater than mean femur biepicondyle breadth of

Discus, Hammer and Javelin throwers. Further mean Femur Biepicondyle breadths of Discus throwers is also significantly greater than mean femur biepicondylar of Hammer and Javelin throwers and mean femur biepicondyle breadths of Javelin thrower is significantly the least from all the three groups.

Shot putters need more stability during taking glide for putting shot to maximum distance. Greater femur & humerus biepicondylar provides greater stability and base for muscular attachment, this helps in greater application of muscular force.

Hammer throwers also need more stability during turning movement for throwing the Hammer to maximum distance. Shot putters are using linear application of force to propel the Shot where as Hammer thrower is using centrifugal force. Therefore the requirement of femur & humerus biepicondyle breadth for Shot putters are greater than Hammer throwers.

In Discus throw principles of aerodynamics are used. Discus thrower requires greater speed during turning movement to create greater centrifugal force with stability. Therefore the requirement of femurs & humerus biepicondylar for Discus thrower is lesser than Shot putter and Hammer thrower.

Javelin also moves under the principles of aerodynamics. They need greater speedy and efficient execution of the technique. They need a natural shoulder jerk. Therefore they are having lesser femur & humerus biepicondyle widths of all the throwers.

These findings are in line with the study conducted by Sidhu and Wadhan (1975) who found throwers to be heavy and tall with relatively large limb circumferences and bicondylor diameters, they had better

developed lean tissue in the limbs associated with greater amount of fatty tissue.

ENDOMORPHY

Comparing the pair wise mean difference with critical difference we are able to conclude that mean endomorphy of Shot putter is significantly greater than mean endomorphy of Hammer, Discus and Javelin throwers. Further mean endomorphy of Hammer thrower is significantly greater than mean endomorphy of Discus and Javelin throwers and mean endomorphy of Javelin thrower is significantly the least from all the three groups.

Shot putter need maximum explosive strength for putting the Shot to greater distance, for this they require great muscular body along with greater fat mass for resisting opposite reactionary force of Shot (Newton's IIIrd low motion)

Hammer thrower also need greater endomorph body for counteracting centrifugal force while taking turn. Shot putters are using linear application of force to propel the Shot where as Hammer throwers are using centrifugal force. Therefore the requirement of endomorph body for shot putter is greater than Hammer thrower.

In Discus throw principles of aerodynamics are used. Discus throwers are less endomorphic in comparison to Shot putter & Hammer thrower. Discus thrower requires greater speed during turning movement to create greater centrifugal force. Therefore the requirement of endomorphy for Discus throw is lesser than Shot putter and Hammer thrower.

Javelin also moves under the principles of aerodynamics. As the weight of Javelin is only 800 gram therefore the requirement of maximum strength is not there. Javelin throwers need greater power to execute the throw to maximum distance. They need a natural shoulder jerk. Therefore they are the lightest of all the throwers.

MESOMORPHY

Comparing the pair wise mean difference with critical difference we are able to conclude that mean mesomorphy of Shot putter is significantly greater than mean mesomorphy of Discus, Javelin and Hammer throwers. Further mean mesomorphy of Discus is also significantly greater than mean mesomorphy of Javelin and Hammer throwers and mean mesomorphy of Hammer thrower is significantly the least from all the three groups.

Shot putters need maximum explosive strength of all the throwers to propel the shot to maximum distance. They had to apply linear force on a shot of 7.26 kg. Hammer throwers use rotational force to throw the Hammer of 7.26 kg. They also need maximum explosive strength, but lesser than Shot putters. There for muscle girths of hammer throwers are lesser than Shot putters.

Discus throwers need greater speed with power to throw the Discus of only 2kg weight, Therefore the requirement of greater muscular girth for maximum strength does not exist much in them in comparison to Hammer throwers and Shot putters.

Javelin thrower use natural shoulder jerk to throw the Javelin of 800 gm weight. They need maximum speed. Therefore the requirement of greater muscular mass is least for them among all the throwers.

ECTOMORPHY

Comparing the pair wise mean difference with critical difference we are able to conclude that mean ectomorphy of Javelin throwers is significantly greater than mean ectomorphy of Discus, Hammer throwers and Shot putters. Further mean ectomorphy of Discus thrower is significantly greater than mean ectomorphy of Hammer and Shot putter and mean ectomorphy of Shot putters is significantly the least from all the three groups.

Shot putters are using linear application of force where as Hammer throwers and Discus throwers use centrifugal force to propel their respective implements. Less ectomorphy of Hammer and Discus thrower is compensated by getting more stability. Greater stability helps in speedy turning movement resulting in the development of greater centrifugal force. Javelin is of lighter weight of all the four implements, it moves under the principles of aerodynamics, a powerful natural jerk of shoulder is necessary to execute the throw to maximum distance. The excess ectomorphy of javelin thrower helps in efficient execution of technique and creation of powerful shoulder jerk.

PONDERAL INDEX

Comparing the pair wise mean difference with critical difference we are able to conclude that mean ponderal index of Javelin throwers is significantly greater than mean ponderal index of Discus, Hammer and Shot putter. Further mean ponderal index of Discus thrower is significantly greater than mean ponderal index of Hammer throwers and

Shot putter and mean ponderal index of Shot putter is significantly the least from all the three groups.

Shot putters are using linear application of force where as hammer and Discus throwers use centrifugal force to propel their respective implements. Getting more stability compensates lesser height/weight of hammer and Discus thrower. Greater stability helps in speedy turning movement resulting in the development of greater centrifugal force. Javelin is the lighter of all the four implements, it moves under the principles of aerodynamics, a powerful natural jerk of shoulder is necessary to execute the throw to maximum distance. Therefore effective technique and powerful natural shoulder jerk compensate requirement of height/weight.

UPPER ARM LENGTH –LOWER ARM LENGTH INDEX

Comparing the pair wise mean difference with critical difference we are able to conclude that mean upper arm length –lower arm length index of shot putter is significantly greater than mean Upper arm length – lower arm length index of Javelin, Hammer and Discus throwers. Further mean upper arm length –lower arm length index of Javelin throwers is also significantly greater than mean upper arm length –lower arm length index of Hammer and Discus thrower and mean upper arm length –lower arm length index of Discus thrower is significantly the least from all the three groups.

Shot putters had greater upper arm length-lower arm length index, which means that, they had greater upper arm length than lower arm length; Shot putters need maximum strength to execute linear propulsion

force on the shot. Which is propelled through powerful and longer deltoid and biceps muscles.

The Javelin throwers greater lower arm length gives them a greater force arm, which helps them in giving powerful jerk to the Javelin during throw.

Further greater lower arm length of Hammer and Discus throwers also increase the force arm, which create greater range of movement and centrifugal force during throw. Dyson (1963) has propounded that while throwing the discus, the speed of the discus at the moment of release is of prime important in determining how far it will go, and for give angular velocity (dependent on how fast the 'lever' throwing the discus, i.e. to the distance of the discus from the axis of the thrower; hence the desirability of having long and powerful arms.

HIP BREADTH-STATURE INDEX

Comparing the pair wise mean difference with critical difference we are able to conclude that mean hip breadth-stature index of Shot putter is significantly greater than mean hip breadth-stature index of Discus, Javelin and Hammer throwers. Further mean hip breadth-stature index of Discus is also significantly greater than mean hip breadth-stature index of Javelin and Hammer throwers, and mean hip breadth-stature index of Hammer thrower is significantly the least from all the three groups.

Shot putter needs greater hip breadth-stature index for putting the Shot to maximum distance. Greater hip & shoulder breadth signifies greater bone surface and muscular mass. Which gives greater stability and power, Greater stability gives more resistance to counteract opposite reactionary force of shot.

Hammer thrower also need greater weight for counteracting centrifugal force while taking turn. Shot putters are using linear application of force to propel the shot where as Hammer thrower is using centrifugal force. Therefore the requirement of hip breadth-stature index for Shot putter is greater than Hammer thrower.

In Discus throw principles of aerodynamics are used. Discus throwers are having lesser hip breadth-Stature index in comparison to Shot putters & Hammer throwers. Discus thrower requires greater speed during turning movement to create greater centrifugal force. Therefore the requirement of hip breadth-stature index for Discus thrower is lesser than Shot putter and Hammer thrower.

Javelin also moves under the principles of aerodynamics. Javelin throwers need greater power to execute the throw to maximum distance. They need a natural shoulder jerk. Therefore their hip breadth and stature index is the least of all the throwers.

SHOULDER BREADTH-STATURE INDEX

Comparing the pair wise mean difference with critical difference we are able to conclude that mean Shoulder breadth-Stature Index of Hammer thrower is significantly greater than mean Shoulder breadth-Stature Index of Javelin thrower, Shot putter and Discus thrower. Further mean shoulder breadth-stature Index of Javelin throwers is also significantly greater than mean Shoulder breadth-Stature Index of Shot putter and Discus thrower and mean Shoulder breadth-Stature Index of Discus thrower is significantly the least from all the three groups.

FAT PERCENTAGE (%)

Comparing the pair wise mean difference with critical difference we are able to conclude that mean Fat % of Shot putter is significantly greater than mean Fat % of Hammer, Discus and Javelin throwers. Further mean Fat % of Hammer throwers is also significantly greater than mean Fat % of Discus thrower and Javelin thrower and mean Fat % of Javelin thrower is significantly the least from all the three groups.

Shot putters need maximum explosive strength of all the throwers to propel the Shot to maximum distance. They had to apply linear force on a Shot of 7.26 kg. Hammer throwers use rotational force to throw the Hammer of 7.26 kg. They also need maximum explosive strength, but lesser than Shot putters. Therefore Fat % of hammer throwers are lesser than Shot putters.

Discus throwers need greater speed with power to throw the Discus of 2kg. Therefore the requirement of greater Fat % for maximum strength does not exists much for them.

Javelin thrower use natural shoulder jerk to throw the javelin of 800 gm. They need maximum speed, in which excess fat may create hindrance; therefore fat % of Javelin throwers is least of all throwers.

Thus we see that significant differences in majority of physical variables of different groups of throwers exist. In the end we conclude that these differences are partly due to heredity and the different training regimens followed by these athletes. Their definite anthropometrical profile is in line with the mechanical requirement of their throwing events.

The review of various research studies in light of our finding is leading us to conclude that the observed significant differences in the

various anthropometrical variables of different throwers are decisive determinants of the performance limits binding these throwers. Which is confirming the fact that competitive sport, demands events specific physical structure.

A top-level performance demands a particular type of body size shape and proportion. Numerous researchers had observed high co-relation between the body profile of athletes and performance in specific tasks. Hirata had suggested that nation with people whose general physique is limited to the characteristics of champions in certain events must concentrate their training program on those events only.

Carter had also suggested that the athletes who wish to achieve success in sports at high level must compare their physique with Olympic athletes.

Thus our findings are setting guideline for coaches and up-coming athletes, for comparing their physical structure with the different throwers of our country. If their structure is inline with the high performers then they may also achieve their status, subject to the optimization of other factors.

Chapter –v

Summary , Conclusion and Recommendation

SUMMARY, CONCLUSION AND RCOMMENDATION

The human physique differs in a thousand ways. It can be analyzed by studying the size, shape and proportion form of an individual. For this purpose, a set of selected anthropometrics measurements are taken on an individual. The inter group comparisons are made to understand the physical peculiarities of a population. From such body measurements, it is also possible to estimate the distribution of fat and development of bone and muscle in one's body. This is known to be more important in the case of athletes and sportsmen where the physical fitness plays a vital role in the competitive performance.

Mc Ardle et al. pointed out that athlete generally have physique characteristics unique to their specific sports. For example field events athletes have relatively large quantities of lean tissues and a high percentage of body fat where as long distance runners have the least amount of lean tissue and fat mass.

Sports sciences have a long history of studying physique. **Sheldon et at.** Used photoscopic and anthropometric methods to describe individual physique as three different Somatotype viz; (i) Endomorphy (fatty: predominance of digestive organs, softness and roundness of contour throughout the body), (ii) Mesomorphy (muscular: predominance of muscles, bones and connective tissues) and (iii) Ectomorphy (predominance of surface area over body mass linearity). This method has basic shortcoming i.e., it does not quantify the various body dimensions, indices and ratios. The body profile

technique of **Mc Ardle et al.** Describes physique in terms of muscular and non muscular components. The diversity in overall body dimensions can be compared among individuals or groups from that of reference man and reference woman.

Track and field consists of running, hurdling, jumping, and throwing events held between individuals and teams at indoor and outdoor meets. The running and hurdling competitions make up the track events, while the jumping and throwing contests comprise the field events. In many countries the sport as a whole is called *Athletics.* The throws (Shot put, Discus, Javelin, and Hammer) are field events in athletics. They are measure for explosive strength (power) in a human being from ancient time to modern time. The throwers of Shot put, Discus, Javelin and Hammer differed greatly in physique from the other athletes. As a group, they are taller and heavier, with longer arms in relation to their legs. They had broader shoulders and broader hips even for their trunk size, and were somewhat fatter than the track athletes. Their proportions of legs to the trunk were similar to those of middle distance runners. In ancient time throws were used in hunting and warfare. In modern time throws are used for achieving awards or medals in National and International level competitions.

The greater size of the throwers in all dimensions contributes to increase the proportionally body weight of these athletes. The stresses of weight bearing in the case of throwers may be responsible for broadening their knee. The better development of the lean body mass will help them to provide the great strength required in the throwing events.

For the purpose of this study 25 elite male throwers of each Javelin, Shot put, Discus and Hammer throw were selected from various National and Inter-National tournaments, State and SAI hostels and India camp.

The selected subjects belonged to the 15 states of India. Namely -U.P, Punjab, Haryana, Delhi, Bihar, Chhatishgarh, Jharkhand, Karnataka, Kerala, M.P, Maharashtra, Uttaranchal, J & K, West Bengal, Andhra Pradesh, Tamilnadu.

The criterion measures for this study were-

Weight – Kilogram, Anthropometrical parameters - Centimeter and mm., Proportionality (indices) – Ratios, Somatotype - Grading., Body compassion- (%).

The study was delimited to the following anthropometrical parameters

Weight, Height, Sitting Height, Femur Biepicondylar diameter, Humerus Biepicondylar Diameter, Hip Breadth, Shoulder Breadth, Total age, Total Arm Length, Wrist Breadth, Training age, Biceps Muscle Girth, Calf Muscle Girth, Thigh Length, Forearm muscles girth, Chest girth, Chest depth, Total leg length, Lower leg length, Upper leg length, Lower arm length, Upper leg length, Triceps skin fold, Suprailiac skin fold, Sub-scapular skin fold, Thigh skin fold, Body composition, Foot length.

Somatotype: Heath and Carter Method, 1984

Body proportionality: 1) Sitting height - stature index, 2) ponderal index, 3) Thigh length - lower leg length index, 4) Upper arm length - lower arm length index, 5) Hip breadth - stature index, 6) Shoulder breadth - stature index.

Product moment correlation technique, analysis of variance and LSD test were used to find out the significant differences and relationship among above mentioned delimited variable of different groups of throwers, and their performances.

The statistical analysis reveled significant differences among the following variable of different throwers, the results of LSD test in descending order are presented below:

1) **Weight** - shot put<discus<hammer<javelin,
2) **Height** - discus<shot put< javelin< hammer,
3) **Femur Biepicondylar diameter**- shot put<discus<hammer < Javelin,
4) **Humerus Biepicondylar Diameter** – shot put<discus<javelin < hammer,
5) **Hip Breadth**-shot put<discus < javelin < hammer,
6) **Shoulder Breadth**- shot put <javelin <hammer < discus,
7) **Total Arm Length**-javelin<discus< shot put < hammer,
8) **Wrist Breadth**- shot put<javelin<discus< hammer,
9) **Skin Fold**- shot put< hammer<discus<javelin,
10) **Biceps Muscle Girth**- shot put< discus<hammer < javelin,
11) **Calf Muscle Girth**- shot put<discus<hammer <javelin
12) **Thigh Length**- shot put<discus< javelin<hammer,
13) **Forearm muscles girth**- discus<shot put < hammer<javelin,
14) **Chest girth**- shot put<hammer< discus< javelin,
15) **Chest depth**- shot put<discus<hammer<javelin,
16) **Total leg length**- discus<hammer < javelin < shot put,
17) **Endomorphy**- Shot put<Hammer<Discus<Javelin,
18) **Mesomorphy**- shot put<discus< javelin<hammer,

19) **Ectomorphy** - javelin <discus<hammer< shot put,

20) **Ponderal Index-** javelin< discus < hammer < shot put,

21) **Upper arm length -lower arm length-** shot put< javelin< hammer < discus,

22) **Hip breadth-Stature index-** shot put< discus< javelin< hammer,

23) **Shoulder breadth-Stature index**-hammer<javelin<shot put< discus.

24) **FAT %-** Shot put < discus < javelin < Hammer

The statistical analysis revealed insignificant differences among the following variable of Shot put, Discus, Javelin and Hammer throwers : -

1) **Total age**
2) **Sitting height**
3) **Foot length**
4) **Sitting height –statue index**
5) **Thigh length –lower leg length index**

Further correlation ship between variables of different groups of throwers and their performance was find out through product moment correlation technique. The inter group comparison of correlation between selected variables of different groups and their performances is given in table -168.

TABLE –168

INTER GROUP COMPARISONS OF CORRELATION

VARIABLES	SP	DT	JT	HT
Total age & total training	0.38	0.19	0.07	0.55
Height-	0.31	-0.13	0.15	0.26
Weight	0.72	0.51	-0.33	0.23
Sitting height	0.09	0.45	-0.08	0.6
Chest girth & depth	0.45	-0.33	0.4	0.19
Humerus & femur-biepicondylar	0.75	0.74	-0.19	0.28
Wrist & Ankle breadth	0.66	-0.29	- 0.15	0.17
Hip & Shoulder breadth	0.12	-0.14	0.05	0.17
Upper arm length	0.57	-0.22	-0.29	0.23
Lower arm length	0.26	0.04	-0.39	0.06
Total arm length	0.76	0.1	-0.03	0.83
Upper leg length	0.49	-0.38	0.23	0.12
Lower leg length	0.37	-0.32	0.46	0.02
Total leg length	0.08	0.05	0.26	0.31
Muscles girths	0.87	-0.33	0.32	0.09
Skin folds	0.55	0.08	0.06	0.22
Endomorphy	0.43	0.11	0.06	0.15
Mesomorphy	-0.22	-0.33	0.12	-0.04
Ectomorphy	-0.48	0.37	0.25	-0.3
Sitting height-stature Index	0.19	0.22	-0.18	0.24
Ponderal Index	-0.48	0.37	0.23	-0.3
Thigh Length –Lower Leg length Index	0.04	0.02	-0.18	0.07
Upper arm length-Lower arm length	0.38	-0.3	0.23	0.24
Hip breadth-Stature Index	-0.06	-0.46	0.14	-0.11
Shoulder breadth-Stature Index	0.04	-0.34	-0.34	0.02
Fat Percentage	0.54	0.09	0.16	0.03
Foot length	-.018	-.002	-.36	.207

The review of various research studies in light of our finding is leading us to conclude that the observed significant differences in the various anthropometrical variables of different throwers are decisive determinants of the performance limits binding these throwers. Which is confirming the fact that competitive sport, demands events specific physical structure.

A top-level performance demands a particular type of body size shape and proportion. Numerous researchers had observed high co-relation between the body profile of athletes and performance in specific tasks. Hirata had suggested that nation with people whose general physique is limited to the characteristics of champions in certain events must concentrate their training program on those events only.

Carter had also suggested that the athletes who wish to achieve success in sports at high level must compare their physique with Olympic athletes.

Thus our findings are setting guideline for coaches and up-coming athletes for comparing their physical structure with the different group of throwers of our country. If their structure is inline with the high performers then they may also achieve their status, subject to the optimization of other factors.

CONCLUSIONS

After going through the analysis of results in light of literature available, we are able to draw following conclusions:

1. The Shot putters are having greater weight and chest depth than Discus throwers followed by Hammer and Javelin throwers.
2. The Discus throwers are having greater height than Shot putters followed by Javelin and Hammer throwers.
3. The Discus throwers are having greater sitting height than Javelin throwers followed by Shot put and Hammer throwers.
4. The Shot putters are having greater femur Biepicondylar diameter than Discus throwers followed by Hammer and Javelin throwers.
5. The Shot putters are having greater humerus biepicondylar diameter than Discus throwers followed by Javelin and Hammer throwers.
6. Shot putters are having greater hip widths and thigh lengths than Discus throwers followed by Javelin and Hammer throwers.
7. Shot putters are having greater shoulder breadth than Javelin followed by Hammer and Discus throwers.
8. Discus throwers are having greater total age than Javelin followed by Hammer and Shot put throwers.
9. Javelin throwers are having greater total arm length than Discus throwers followed by Shot put and Hammer throwers.
10. Shot putters are having greater wrist breadths than Javelin throwers followed by Discus and Hammer throwers.

11. Shot putters are having greater skin folds than Hammer throwers followed by Discus and Javelin throwers.
12. Shot putters are having greater biceps and calf muscle girths than Discus throwers followed by Hammer and Javelin throwers.
13. Discus throwers are having greater forearm muscle girths than Shot putter followed by Hammer and Javelin throwers.
14. Shot putters are having greater chest girth than Hammer throwers followed by Discus and Javelin throwers.
15. Discus throwers are having greater total leg length than Hammer throwers followed by Javelin and Shot put throwers.
16. Shot putters are having greater endomorphy than Hammer throwers followed by Discus and Javelin throwers.
17. Shot putter are having greater mesomorphy than Discus throwers followed by Javelin and Hammer throwers.
18. Javelin throwers are having greater ectomorphy and ponderal index than Discus throwers followed by Hammer and Shot putter.
19. Javelin throwers are having greater sitting height – stature index than Discus throwers followed by Shot put and Hammer throwers.
20. Javelin throwers are having greater thigh –lower leg length index than Shot putter followed by Hammer and Discus throwers.
21. Shot putters are having greater upper arm length –lower arm length than Javelin throwers followed by Hammer and Discus throwers.

22. Shot putters are having greater hip breadth-statute index than Discus throwers followed by Javelin and Hammer throwers.
23. Hammer throwers are having greater shoulder breadth- stature index than Javelin throwers followed by Shot put and Discus throwers.
24. Shot putters are having greater fat % than Discus throwers followed by Javelin and Hammer throwers.
25. Javelin throwers are having greater foot length than Shot putters followed by Discus throwers and Hammer throwers.
26. Positive correlations were observed between the following variables of Shot putters and their performances
    - Total age & training age (0.38)
    - Height (0.31), Sitting height(0.09)
    - Weight (0.72)
    - Chest girth &depth (0.45)
    - Humerus &femur- biepicondylar (0.75)
    - Wrist & ankle breadth (0.66)
    - Hip &shoulder breadth (0.12)
    - Upper arm length (0.57), lower arm length (0.26)and total arm length (0.76)
    - Upper leg length (0.49), lower leg length (0.37),and total leg length (0.08)
    - Muscle girths (0.87)
    - Skin folds (0.55)
    - Endomorphy (0.43)
    - Sitting height –stature index (0.19)

- Thigh length –lower leg length index (0.04)
- Upper arm length –lower arm length index (0.38)
- Shoulder breadths-stature index (0.04)
- Fat % (0.54)

27. Negative correlations were observed between the following variables of Shot putters and their performances.
    - Mesomorphy (-0.22)
    - Ectomorphy (-0.48)
    - Ponderal index (-0.48)
    - Hip breadth –stature index (-0.06)
    - Foot length (-0.018)
28. Positive correlations were observed between the following variables of Discus throwers and their performances.
    - Total age & total training age (0.19)
    - Weight (0.51)
    - Sitting height (0.45)
    - Humerus &femur-biepicondylar (0.74)
    - Lower arm length (0.04)
    - Total arm length (0.1)
    - Total leg length (0.05)
    - Skin folds (0.08)
    - Endomorphy (0.11)
    - Ectomorphy (0.37)
    - Sitting height-stature index (0.22)
    - Ponderal index (0.37)
    - Thigh length –lower leg length index (0.02)

- Fat %(0.09)

29.Negative correlations were observed between the following variables of Discus throwers and their performances.

- Height (-0.13)
- Chest girth &depth (-0.33)
- Wrist & ankle breadth (-0.29)
- Hip &shoulder breadth (-0.14)
- Upper arm length (-0.22)
- Upper leg length (-0.38)
- Lower leg length (-0.32)
- Muscles girths (-0.33)
- Mesomorphy (-0.22)
- Upper arm length –lower arm length index (-0.3)
- Hip breadth –stature index (-0.46)
- Shoulder breadth –stature index (-0.34)
- Foot length (-0.002)

30.Positive correlations were observed between the following variables of Javelin throwers and their performances.

- Total age &total training age (0.07)
- Height (0.15)
- Chest girth &depth (0.4)
- Hip & shoulder breadth (0.05)
- Upper leg length (0.23)
- Lower leg length (0.46)
- Total leg length (0.26)
- Muscles girths (0.32)

- Skin folds (0.06)
- Endomorphy (0.06)
- Mesomorphy (0.12)
- Ectomorphy (0.25)
- Ponderal index (0.23)
- Upper arm length –lower leg length index (0.23)
- Hip breadth –stature index (0.14)
- Body composition (0.16)

31.Negative correlations were observed between the following variables of Javelin throwers and their performances.

- Weight (-0.33)
- Sitting height (-0.08)
- Humerus & femur biepicondylar (-0.19)
- Wrist &ankle breadth (-0.15)
- Upper arm length (-0.29)
- Lower arm length (-0.39)
- Total arm length (-0.03)
- Sitting height –stature index (-0.18)
- Thigh length –lower length index (-0.18)
- Shoulder breadth –stature index (-0.34)
- Foot length (-0.36)

31. Positive correlations were observed between the following variables of Hammer throwers and their performances.

- Total age & training age (0.55)
- Height (0.26)
- Weight (0.23)

- Sitting height (0.6)
- Chest girth &depth (0.19)
- Humerus &femur biepicondylar (0.28)
- Wrist and ankle breadth (0.17)
- Hip and shoulder breadth (0.17)
- Upper arm length (0.23)
- Lower arm length (0.06)
- Total arm length (0.83)
- Upper leg length (0.12)
- Lower leg length (0.02)
- Total leg length (0.31)
- Muscles girths (0.09)
- Skin folds (0.22)
- Endomorphy (0.15)
- Sitting height –stature index (0.24)
- Thigh length –lower leg length index (0.07)
- Upper arm –lower arm length index (0.24)
- Shoulder breadths –stature index (0.02)
- Body composition (0.03)
- Foot length (0.207)

32. Negative correlations were observed between the following variables of Hammer throwers and their performances.
    - Mesomorphy (-0.04)
    - Ectomorphy (-0.3)
    - Ponderal index (-0.3)
    - Hip breadth –stature index (-0.11)

RECOMMENDATIONS

In light of the findings of our study following recommendation are made-

(1) The findings of the study should be taken into consideration while going for talent hunts for probable high potential throwers of different throwing events.

(2) Along with physical and physiological parameters, psychological and mechanical parameters of different throwers should also be studied.

(3) Further, a study should be conducted to compare elite male Indian throwers with the rest of world selected throwers in relation to physical, physiological and mechanical parameters.

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and

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Appendix

APPENDIX

SHOT PUT

Candidate Name	State	Total age	Total Training age	Weight (Kg)	Height -cm	Sitting Height-cm	Chest Girth-cm	Chest Depth-cm	Humerus Bi-epicondlar	Femur Bi-epicondlar	Wrist width	Hip width (cm)	Shoulder width (cm)	Upper arm length	Lower arm length	Complete arm length	Upper leg length	Ankle width	Lower leg length	Total leg length	Biceps muscle girth	Calf muscle girth	Thigh muscle girth	Fore arm muscle girth	Triceps skin fold	Subsacapular skin fold	Supra iliac skin fold	Calf skin fold	Thigh skin fold	Foot length	Performance
Sanat K. Mishra	UP	32	12	110	186	99	119	24	6	10	6	33	46	35	31	76	49	7	44	112	40	43	69	34	18	23	27	12	17	27	17.30
Naw preet Singh	P	26	8	125	187	97	115	25	7	10.5	6.5	31	42	44	34	79	64	8	49	110	41	49	71	33	20	28	32	22	28	28	19.93
Kulwender Singh	P	24	7	103	175	88	116	23	7.5	9	6.5	32	37	38	30	79	51	7	42	99	42	41	68	34	15	19	13	15	20	28	18.12
Gurpreet Singh	P	24	6	110	182	94	119	26	7	10	6.5	41	48	42	30	82	54	8	46	107	42	44	70	36	23	24	18	21	17	27	17.92
Mukesh Singh	MR	28	10	105	184	90	107	25	8	11	7	36	41	42	33	78	53	7.5	51	107	38	41	65	33	20	18	13	18	17	28	18.22
Kuldeep Main	P	26	6	115	183	93	114	26	7	10	6	34	43	40	32	76	56	7	50	106	43	45	69	33	16	27	28	23	15	27	18.56
Kamaluddin Mandal	WB	23	4	102	178	92	107	24	7	9.5	6	36	45	36	30	78	51	7.5	46	108	39	45	66	31	9	23	15	12	12	29	16.5
Satendra Kumar	UP	20	4	117	184	96	95	25	6.5	9	6.5	32	45	41	28	75	52	8	44	98	43	45	70	32	22	15	18	14	19	27	18.26
Vijay Kumar	V	24	10	112	183	94	94	26	7	10	6.5	33	46	42	30	81	48	7	43	97	41	45	68	31	12	10	15	18	20	29	18.21
Darshan Kumar	UP	23	6	86	176	87	89	20	6.5	9	6	30	38	36	30	75	52	7	40	97	36	40	61	30	8	10	15	8	10	28	16.60
Rajeev Shrama	JH	27	8	98	185	94	101	23	7	9	7	33	35	38	31	80	51	7	47	95	35	40	62	30	8	10	12	14	13	27	16.40
Ran Vijay	UP	25	8	107	186	97	114	22	8.5	11	6.5	41	42	42	30	77	59	7.5	41	101	41	44	70	32	14	23	18	11	15	27	20.26
Durveen Singh	UP	23	6	84	173	92	104	21	8	10	7	40	41	40	30	80	54	7	39	97	40	42	67	31	10	15	10	12	10	30	16.75

UP=Utter Pradesh, MP= Mandhay Pradesh, HP= Himachal Pradesh, P= Panjab, H= Hariyana, RJ=Rajisthan, MR=Maharashtra, V=Vihar, JK=Jaharkhand, Chh=Chhatisgarh, WB=Weast Bangal, UK=Uttra khand, GR=Gajrat, AP=Andra Pradesh, TN=Tamilnadu, K=Kerala, D=Delhi.

Candidate Name	State	Total age	Total Training age	Weight (Kg)	Height -cm	Sitting Height-cm	Chest Girth-cm	Chest Depth-cm	Humerus Bi-epicondlar	Femur Bi-epicondlar	Wrist width	Hip width (cm)	Shoulder width (cm)	Upper arm length	Lower arm length	Complete arm length	Upper leg length	Ankle width	Lower leg length	Total leg length	Biceps muscle girth	Calf muscle girth	Thigh muscle girth	Fore arm muscle girth	Triceps skin fold	Subsacapular skin fold	Supra iliac skin fold	Calf skin fold	Thigh skin fold	Foot length	Performance
Kulvindra Singh	P	25	7	100	180	92	103	24	8	10	7	40	40	39	30	78	58	7	39	98	40	43	69	30	10	15	15	15	18	28	17.80
Sukhadev Singh	P	25	6	98	187	98	115	24	9	10	7	42	44	43	32	78	58	7.5	40	103	42	45	72	34	13	20	15	18	19	28	17
Sandeep Kumar	UP	25	5	102	190	94	107	21	8	9	7	41	40	40	32	80	57	7	40	107	42	45	70	33	10	8	12	10	15	29	16.80
Jaiveer Singh	HR	33	8	125	192	96	124	27	7.5	11	7	43	41	48	31	75	58	8	39	105	43	46	73	35	13	18	15	12	12	28	19.18
Pakinder Singh	P	26	5	110	178	90	105	23	7	10	7	42	40	39	31	77	56	7	40	102	40	42	68	33	10	12	15	10	14	28	17.20
Shakti Singh	HR	35	15	127	186	95	147	25	8	10	7	40	42	40	32	88	58	8	47	115	42	44	76	37	20	18	25	22	25	27	20.28
Bahadur Prashad	HR	28	10	107	185	96	128	23	7	10	7	39	42	41	30	81	54	7	40	107	39	41	64	32	10	12	15	13	12	29	16.7
Deewan Singh	UP	28	9	118	187	95	110	25	8	10	7	42	42	40	30	80	58	7	41	105	40	44	70	34	10	15	18	12	20	28	18.05
Rupendra Malik	UP	27	7	108	183	92	104	23	8	9	7	41	43	38	30	79	56	7	40	102	41	42	66	32	15	12	20	8	10	28	17.07
Ajay Kumar	V	23	5	98	182	90	97	22	7	9	7	38	41	39	31	78	57	7	38	101	40	41	65	32	8	18	12	17	12	27	16.82
Hemant Chaudh.	UP	24	6	92	175	91	98	21	7	9	7	40	41	38	32	80	55	7	40	100	39	42	62	34	10	15	18	15	16	27	17.51
Deepak Mishra	V	23	5	105	180	95	106	23	7	11	6	35	39	39	30	77	52	8	45	106	39	48	68	33	20	19	40	17	20	28	16.5

Discus throw

Candidate Name	State	Total age	Total Training age	Weight (Kg)	Height -cm	Sitting Height-cm	Chest Girth-cm	Chest Depth-cm	Humerus Bi-epicondlar	Femur Bi-epicondlar	Wrist width	Hip width (cm)	Shoulder width (cm)	Upper arm length	Lower arm length	Complete arm length	Upper leg length	Ankle width	Lower leg length	Total leg length	Biceps muscle girth	Calf muscle girth	Thigh muscle girth	Fore arm muscle girth	Triceps skin fold	Subsacapular skin fold	Supra iliac skin fold	Calf skin fold	Thigh skin fold	Foot length	Performance
Hardia Nand	V	30	12	85	187	99	96	22	6.5	10	6	31	43	42	39	85	52	7	45	117	35	40	60	31	11	15	20	10	15	28	56.81
Sukh veer Singh	P	27	8	92	182	94	102	25	7	10.5	6.5	34	38	39	35	78	48	7	41	101	39	42	65	36	20	20	25	18	25	27	56.10
Bal krishnan	H	26	9	87	180	90	100	22	7	10	6	32	36	38	35	76	47	7.5	42	99	34	39	62	32	10	15	20	9	12	28	55.10
Kurswak	H	28	10	90	179	90	104	24	7.5	10	6.5	30	32	33	32	75	48	7	41	108	38	40	65	35	15	20	18	10	12	28	56.07
Deo Kumar	P	27	9	86	181	94	98	20	7	9	6	31	30	32	30	72	48	7	40	110	36	41	63	32	9	10	15	10	15	27	55.62
Naresh Kumar	MP	28	10	88	183	96	103	24	7	10	6	32	35	36	33	79	51	7	46	115	36	40	62	30	12	15	20	10	15	28	53.72
Devendra Singh	HP	27	8	91	184	98	107	25	7	10	6	34	36	37	35	80	52	7	48	117	37	42	66	34	18	14	20	9	12	28	57.10
Devinder Singh	UK	26	8	87	180	92	96	22	6.5	10	6	32	40	38	34	79	48	7	41	102	33	38	61	31	10	15	12	15	20	28	54.15
Amrit pal Singh	D	27	8	90	187	94	98	24	7	9	6	33	40	39	36	80	49	7	42	100	35	40	60	33	15	15	12	16	20	28	54.33
Simaranjeet Singh	H	28	11	90	181	94	97	23	7	10	6	33	42	38	35	80	50	7	40	101	36	39	62	34	12	16	10	15	18	29	54.74
B . Rejesh	V	25	6	85	174	88	95	22	7	10	6	34	40	38	35	79	50	7	41	10	37	40	64	35	10	10	15	8	12	28	51.06
Sandeep Kumar	UP	25	6	102	190	94	107	21	8	9	7	41	42	40	32	80	57	7	40	107	42	45	70	33	10	8	12	10	15	28	50.74
Ajay Kumar	MP	26	6	82	183	95	98	20	7	9	6	32	35	35	33	78	52	7	47	116	37	42	65	32	11	12	18	8	15	28	50.62
Jagjeet Singh	GJ	25	7	92	186	94	101	23	7	10	6	33	40	40	41	87	56	7	48	122	36	39	68	33	10	15	18	12	15	28	53.18

Candidate Name	State	Total age	Total Training age	Weight (Kg)	Height -cm	Sitting Height-cm	Chest Girth-cm	Chest Depth-cm	Humerus Bi-epicondlar	Femur Bi-epicondlar	Wrist width	Hip width (cm)	Shoulder width (cm)	Upper arm length	Lower arm length	Complete arm length	Upper leg length	Ankle width	Lower leg length	Total leg length	Biceps muscle girth	Calf muscle girth	Thigh muscle girth	Fore arm muscle girth	Triceps skin fold	Subsacapular skin fold	Supra iliac skin fold	Calf skin fold	Thigh skin fold	Foot length	Performance
Guru Sevak	P	24	6	87	183	95	98	24	7	10	6	35	41	39	40	80	52	7	43	105	34	48	63	32	12	10	15	10	12	27	52.12
Mandeep Singh	P	25	6	98	185	95	99	22	7	9	6	36	44	41	42	85	54	7	45	110	33	35	62	31	18	18	21	15	15	26	53.80
Anil Kumar	H	28	9	92	187	98	102	22	7	10	6	34	42	42	43	87	56	7	47	123	34	38	61	32	15	12	15	10	12	28	51.22
Monbi	D	25	6	85	181	92	106	25	7	9	6	32	40	38	39	79	51	7	41	102	36	39	64	35	10	12	18	12	15	29	52.01
Anand Kumar	UP	28	9	95	185	95	98	23	7	10	6	38	40	39	40	86	58	7	49	127	32	37	61	33	7	10	12	8	10	28	52.17
Tajendera Singh	HP	29	12	110	187	96	120	24	7	10	6	36	41	35	31	79	50	7	45	115	40	43	68	34	15	20	25	15	15	27	53.17
Anil Kumar	D	30	13	90	190	95	95	22	7	10	6	35	41	39	38	88	58	7	50	128	36	39	63	36	8	10	12	7	10	28	57.28
Jaiveer Singh	UP	31	8	123	192	96	124	27	7.5	11	7	43	41	38	31	75	58	8	59	115	43	46	73	35	13	18	15	12	12	28	48.56
Kulwindra Singh	P	26	7	103	185	95	114	26	7	10	6	35	42	40	32	80	53	7	50	106	43	42	69	33	16	27	27	23	15	27	49.10
Satyaveer Singh	H	25	5	91	181	90	102	21	7	10	6	32	40	38	37	77	51	7	42	106	36	39	60	32	10	12	15	10	15	28	51.17
Bharat Shrama	UP	27	7	96	183	92	105	23	7	10	6	35	43	41	38	79	52	7	44	110	36	38	63	32	12	10	12	8	15	28	50.16

Javelin throw

Candidate Name	State	Total age	Total Training age	Weight (Kg)	Height -cm	Sitting Height-cm	Chest Girth-cm	Chest Depth-cm	Humerus Bi-epicondlar	Femur Bi-epicondlar	Wrist width	Hip width (cm)	Shoulder width (cm)	Upper arm length	Lower arm length	Complete arm length	Upper leg length	Ankle width	Lower leg length	Total leg length	Biceps muscle girth	Calf muscle girth	Thigh muscle girth	Fore arm muscle girth	Triceps skin fold	Subsacapular skin fold	Supra iliac skin fold	Calf skin fold	Thigh skin fold	Foot length	Performance
Umakant Tripathi	UP	31	9	70	176	88	95	20	6	9.5	6.5	27	39	42	32	82	54	7	44	108	30	35	56	27	10	7	9	7	10	27	71.35
Shankar Bishwas	WB	27	12	83	175	90	99	19.1	7	10	6.5	31	37	37	28	72	54	7.5	47	104	38	40	63	29	8	14	19	16	19	28	72.80
Inder jeet singh	P	26	7	90	181	99	97	20	7.5	9.5	6	35	39	39	30	76	49	9	48	104	38	42	65	32	10	11	8	14	13	28	68.3
Ranjeet Mauria	UP	26	7	86	188	95	95	21	7.5	10	6	34	42	38	31	84	59	7	47	114	29	37	58	28	9	10	7	10	7	30	73.2
Jagdish Kumar	D	31	12	76	178	93	92	20	6	6.5	6	30	40	41	32	81	55	7	45	106	30	38	60	30	8	10	12	8	10	27	76.78
Gur Krit Singh	P	27	8	76	178	96	96	22	7	10	6.5	33	42	39	30	80	54	7	41	110	34	40	66	34	15	15	21	12	14	26	74.76
Harminder Singh	H	28	8	85	174	92	98	21	7	10	7	32	41	42	31	78	56	7	41	106	36	37	63	36	16	10	18	16	20	28	68.6
Sudheer Kumar	D	26	7	88	170	90	96	23	7.5	10	7	34	39	41	30	77	53	7	44	109	34	36	64	35	10	10	16	12	14	27	69.1
Dharampal	MP	36	15	85	186	10	94	21	7.5	11	7	32	42	42	36	88	51	7	49	109	35	37	66	34	9	15	11	10	12	26	68.7
M.Bhojral	AP	23	5	79	176	97	94	22	6	9	6.5	30	40	41	32	78	50	8	47	106	36	39	68	36	14	13	20	12	15	27	68.4
Gajendra Kumar	UP	25	5	82	180	94	102	26	7.5	10	7	34	44	36	30	79	49	7	49	102	38	41	66	38	15	15	17	15	18	28	74.16
Fazal Ansari	V	28	11	85	178	92	99	20	8	10	7	33	39	40	36	80	56	8	48	104	39	41	65	30	18	18	15	15	18	28	75.96
Avtar Singh	P	28	12	72	171	90	91	20	6	9	6	28	40	43	35	80	56	7	42	102	30	34	58	28	10	7	9	10	12	29	69.15

Candidate Name	State	Total age	Total Training age	Weight (Kg)	Height -cm	Sitting Height-cm	Chest Girth-cm	Chest Depth-cm	Humerus Bi-epicondlar	Femur Bi-epicondlar	Wrist width	Hip width (cm)	Shoulder width (cm)	Upper arm length	Lower arm length	Complete arm length	Upper leg length	Ankle width	Lower leg length	Total leg length	Biceps muscle girth	Calf muscle girth	Thigh muscle girth	Fore arm muscle girth	Triceps skin fold	Subsacapular skin fold	Supra iliac skin fold	Calf skin fold	Thigh skin fold	Foot length	Performance
Morminder Singh	HP	27	10	88	186	94	93	22	7	10	6.5	30	42	40	33	79	54	7	43	103	29	35	60	27	19	15	10	15	15	28	67.85
Mo. Imran	TN	29	11	79	188	97	94	24	7.5	10	7	32	45	44	36	86	56	7	44	109	30	33	58	28	10	15	18	15	10	27	69.44
Deepender Singh	UP	27	9	95	189	95	93	21	7	10	7	30	41	42	36	82	58	7	45	110	28	28	62	28	8	10	12	10	14	27	72.11
Krishan Kumar	H	26	10	70	170	92	93	20	7	10	6.5	31	40	38	35	80	51	6.5	40	96	26	27	54	26	5	8	10	6	9	30	71.
Shyam Sunder	UP	30	12	68	169	90	94	21	7	10	7	32	41	39	33	79	48	6.5	36	93	27	28	56	27	5	9	12	6	15	28	67.68
Lakhwinder Singh	P	24	6	90	185	94	93	20	7	10	7	31	43	41	35	80	55	7	42	102	30	40	62	28	10	11	10	8	15	29	65
Arun Kumar Patel	JH	26	7	72	175	91	93	21	7	9	6	28	42	43	33	81	56	7	42	103	31	33	60	29	12	7	10	10	12	31	66.45
Sunil Kumar	MR	27	8	78	168	90	88	19	6.5	9	7	30	40	37	34	79	50	7	39	95	27	27	53	27	7	8	10	15	15	28	67.53
Vikram jeet Singh	RJ	24	6	81	170	93	94	21	7	10	7	32	40	39	36	80	51	7	40	98	27	28	54	27	8	9	15	8	15	29	66.76
Dharmender Kumar	RJ	25	6	85	184	94	92	20	7	10	7	33	41	42	36	85	56	7	44	105	27	34	56	26	8	10	15	8	8	28	65.06
Lijesh Kumar	KL	24	8	78	177	90	7	19	7	9	6	31	40	38	30	80	58	7	45	99	33	38	64	29	6.5	8	6	6	9	27	75.56
Anil Kumar	H	22	6	88	188	95	99	20	7	9	6	37	39	44	32	83	58	8	47	105	34	36	59	29	7	8	9	11	9	28	74.79

Hammer throw

Candidate Name	State	Total age	Total Training age	Weight (Kg)	Height -cm	Sitting Height-cm	Chest Girth-cm	Chest Depth-cm	Hemrus Bi-epicondlar	Femur Bi-epicondlar	Wrist width	Hip width (cm)	Shoulder width (cm)	Upper arm length	Lower arm length	Complete arm length	Upper leg length	Ankle width	Lower leg length	Total leg length	Biceps muscle girth	Calf muscle girth	Thigh muscle girth	Fore arm muscle girth	Triceps skin fold	Subsacapular skin fold	Supra iliac skin fold	Calf skin fold	Thigh skin fold	Foot length	Performance
Rakesh Kumar	UP	26	9	92	182	98	108	24	7	9	6	32	44	33	28	75	54	7	46	106	35	38	67	31	13	27	15	14	15	28	70.16
Ishtiyaq Ahmad	UP	30	12	83	174	91	102	20	6.8	10	6	32	43	36	30	77	54	7	45	107	30	35	60	28	13	19	17	15	14	26	70.13
KulWinder Singh	P	24	7	90	181	90	101	22	6.5	9	6	31	41	34	31	76	51	7	42	103	34	38	65	30	15	20	25	19	20	27	67.82
Har Pal Singh	P	26	9	96	186	97	99	20	7	10	6.5	33	44	38	32	82	56	7.2	48	110	36	34	63	32	10	9	15	10	18	29	66.52
Pradeep Kumar	V	24	8	87	178	92	100	18	7	10	6	32	40	34	33	78	52	7	44	108	31	33	62	27	15	18	15	10	15	28	66.1
KarWinder Singh	P	27	11	88	175	90	98	20	6.5	9	6	30	39	35	35	32	50	6.8	42	102	30	31	62	28	9	15	15	8	10	26	65.6
Vijay Singh	H	25	10	82	171	87	94	22	6	9	6	30	38	36	33	77	53	7	46	107	31	34	63	30	10	12	20	15	15	28	66.2
Satish Singh	UP	26	9	86	170	90	92	18	7	10	6	31	36	35	34	78	50	7	43	103	31	32	63	29	9	10	14	9	12	27	66.15
HarBhajan Singh	P	25	10	96	180	94	98	22	7	10	6	32	39	37	35	81	53	7	47	108	32	33	65	31	10	15	20	10	18	27	68.1
Suresh Kumar	JH	26	12	89	182	96	97	20	7	10	6	30	35	35	32	79	51	7	46	107	30	31	60	29	9	12	15	14	20	28	66.5
VeerKaran Singh	H	25	9	92	182	90	107	23	7	9	6	32	42	32	27	74	53	7	44	105	34	37	65	30	15	20	18	19	20	27	65.18
Vipender Singh	GJ	28	11	90	182	92	106	22	7	9	6	31	40	35	30	74	54	7	45	106	36	38	63	32	15	18	15	12	18	28	63.65
Pramod Tiwari	UP	33	16	105	183	96	106	23	7	10	6.5	31	44	35	30	78	56	7	47	110	34	37	63	30	10	20	10	15	18	30	70.05
Vinod Kumar	UP	26	8	95	180	90	107	24	7	10	6.5	32	43	33	27	76	55	7	45	106	35	36	65	31	12	24	15	14	15	28	64.06

Candidate Name	State	Total age	Total Training age	Weight (Kg)	Height -cm	Sitting Height-cm	Chest Girth-cm	Chest Depth-cm	Hemrus Bi-epicondlar	Femur Bi-epicondlar	Wrist width	Hip width (cm)	Shoulder width (cm)	Upper arm length	Lower arm length	Complete arm length	Upper leg length	Ankle width	Lower leg length	Total leg length	Biceps muscle girth	Calf muscle girth	Thigh muscle girth	Fore arm muscle girth	Triceps skin fold	Subsacapular skin fold	Supra iliac skin fold	Calf skin fold	Thigh skin fold	Foot length	Performance
Pargat Singh	D	26	10	92	185	97	98	20	6.5	10	6.5	30	43	36	32	80	57	6.8	47	112	34	38	72	30	8	15	10	10	15	29	63.62
Himansu Misha	UP	25	7	82	178	98	103	24	7	9	6.5	30	43	36	32	80	53	7.2	45	103	32	37	63	32	10	20	8	10	20	27	62.12
Ashish Kumar	MP	25	6	78	168	85	97	23	6.5	9	6	33	40	30	27	75	49	7	44	102	30	35	62	33	15	25	15	10	18	26	62.
Sombeer Singh	UP	25	5	82	176	88	99	22	6.5	9	6.2	34	42	31	29	77	52	7	46	106	31	36	64	34	18	21	15	16	15	27	61.42
Tag Winder Singh	P	24	5	90	185	95	101	20	6.5	10	6	30	44	36	33	81	56	6.8	47	109	34	36	66	33	15	18	12	15	20	28	60.5
Madhu Kumar	D	27	8	87	172	90	107	23	7	9	6	31	42	32	31	78	54	7	46	108	35	37	65	35	12	15	10	15	16	27	66
Ashok Tiwari	V	29	8	90	178	92	102	22	6.5	10	6.2	32	42	33	32	79	55	7	47	108	34	38	63	34	10	20	15	19	25	28	66.2
Lique Ahmad	UP	28	8	78	172	90	98	18	6.5	9	6	31	39	33	30	77	54	6.5	45	106	32	35	58	27	10	15	12	15	12	27	65.15
Hamant Chauhan	UP	26	6	76	171	91	101	21	7	9	6	31	39	33	30	77	53	7	45	106	33	37	64	30	10	10	12	18	12	27	63
Mahesh Chandra	V	25	5	78	169	90	99	20	7	9	6	30	38	31	30	78	52	7	44	102	32	36	61	30	10	12	11	17	11	27	62
Vinod Pandit	UP	27	7	81	168	88	96	21	7	9	6	32	36	32	31	79	54	7	46	103	33	38	62	31	8	10	12	10	10	27	63.15